EXPERIMENT NO 1

Name of experiment

Density and specific gravity of crude oil and its derivatives

the objective of experiment

To measure the density and specific gravity of crude oil and its derivatives and the classification of the type of oil

* **Density:** mass of a unit volume of a material substance. The formula for density is d = M/V, where d is density, M is mass, and V is volume. Density is commonly (experimentally) expressed in units of grams per cubic centimeter. For example, the density of water is 1 gram per cubic centimeter.

It is calculated according to the following formula

p = m/V   where m : mass of liquid

v : volume of liquid

* **The specific gravity:** is the ratio between the density of an object, and a reference substance Usually our reference substance is water which always has a density of 1 gram per milliliter or 1 gram per cubic centimeter.

It is calculated according to the following formula

$$Specific\ Gravity = \frac{density\ of\ the\ object}{density\ of\ water} = \frac{\rho_{object}}{\rho_{H_2O}}$$

* **The American Petroleum Institute gravity, or (API)** : It is a measure of the classification of crude oil into heavy, medium and light based on specific gravity and density

It can be calculated by the formula

API= (141.5/SP)-131.5

where (SP) : specific gravity for oil

if (API) more than 29 it is mean that light crude oil

if (API) value between 20 to 29 it is mean that medium crude oil

if (API) value less than 20 it is mean that heavy crude oil

- We will using two methods to measure density :

1 – Hydrometer

2- pycnometer

First method

Hydrometer

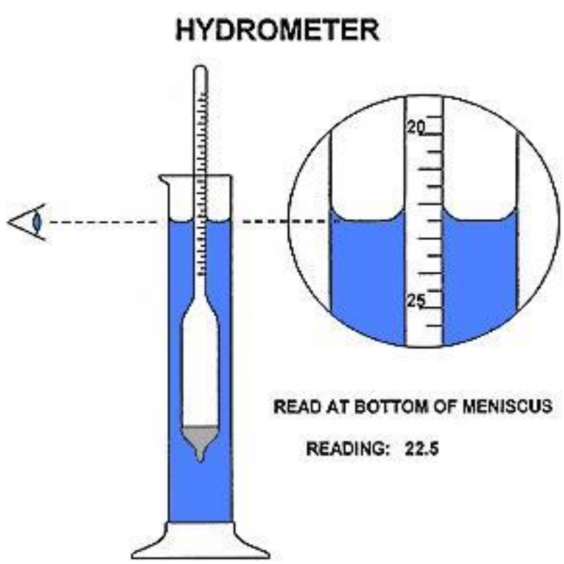
Hydrometer :an instrument for determining the specific gravity of a liquid, commonly consisting of a graduated tube weighted to float upright in the liquid whose specific gravity is being measured.

Tools

1 – Hydrometer 2- cylinder

Procedure

To measure the density by hydrometer method , we fill the cylinder with a liquid then the hydrometer must immersion in petroleum product directly at a certain temperature , the density read when corresponding liquid face with included measure at eye level record the density



Second method

Pycnometer a container Glass used for determining the density of a liquid or powder, having a specific volume.

Tools

1 – pycnometer 2 - Digital balance

Procedure

1 – weight the clean dry pycnometer on the leading balance to record the pycnometer weight only .(W1)

2 – fill pycnometer with liquid and record it (W2)

3 – calculate the density according to the formula :

P = (W1 _ W2) /V

Discussion

1- What are the compounds of crude oil and what are the impurities present ?

2- Compare between the methods (hydrometer and pycnometer)

3- what are the causes error in hydrometer experiment ?

Q /Classify the crude oil and its derivatives by the following data :

1-Mass = 20 gm , vol = 30 ml

2-Mass = 14 gm ,vol = 20 ml

3-Mass = 61 , vol = 92 ml

4-Mass = 43 , vol = 57

Experiment NO 2

Name of experiment

Flash and fire point

Objective of experiment

To determine flash and fire point for crude oil and its derivatives .

Flash and fire point

*The flash point of a flammable liquid is the lowest temperature at which it can form an ignitable mixture in air. At this temperature the vapor may cease to burn when the source of ignition is removed. A slightly higher temperature, the fire point, is defined as the temperature at which the vapor continues to burn after being ignited. Neither of these parameters are related to the temperatures of the ignition source or of the burning liquid, which are much higher. The flash point is often used as one descriptive characteristic of liquid fuel, but it is also used to describe liquids that are not used intentionally as fuels.

The fire point of a fuel is the temperature at which it will continue to burn after ignition for at least 5 seconds. At the flash point, a lower temperature, a substance will ignite, but vapor might not be produced at a rate to sustain the fire. Fire point and autogenous ignition are additional considerations when selecting fire resistant greases.

Importance of flash and fire point

1_ It indicates fire hazards of petroleum and evaporation losses under high temperature

2_ It give us the idea about the maximum temperature which the oil can be used (it is important for storage and transportation)

3_ Detection of pollutants in the given oil product

4_ It classifies the petroleum products (light or heavy)

Methods for measurement flash point

1 – Pensky martens (closed cup test)

2 – Cleveland test (open cup test)

3 – Abel test

Pensky martens (closed cup test) procedure

1 – the apparatus should be completely dried .

2 – the thermometer blub should dip in the oil .

3 – fill the sample of the lubricating oil cup to the mark.

4 –while applying the test flame , stirring should be continued .

5 – when the oil start flashing record the temperature.

WEST TUNE

Cleveland test (open cup test) procedure

1 – the apparatus should be completely dried .

2 – the thermometer blub should dip in the oil .

3 – fill the sample of the lubricating oil cup to the mark.

4 – start heating by heat source , but the heater is regulated.

5 - Give a spark source intermittently until the start of the flash

6 – record the temperature .

Discussion

1 - Talk about the effect of flash point and fire point on the quality of the crude oil product?

2 – what are the factors that effect on fire point and flash point ?

3 – what is the difference between closed cup and open cup methods?

Experiment NO 3

Name of experiment

Ash content

Objective of experiment

To determine ash content in crude oil

Ash content represents the incombustible component remaining after a sample of the furnace oil is completely burned. The ash content of petroleum products is generally low. It is defined as inorganic residue that remains after combustion of the oil in air at specific high temperature. Ash ranges from 0.1–0.2%. The ash content of a fuel is a measure of the amount of inorganic noncombustible material it contains. Some of the ash forming constituents occur naturally in crude oil; others are present as a result of refining or contamination during storage or distribution.

Knowledge of the amount of ash-forming material present in a product can provide information as to whether or not the product is suitable application. The ash content of petroleum products came from the carbon residue of oil.

Procedure of experiment

1-clean the porcelain crucible and dry it for 15 minutes, then weigh it empty after cooling it.

2- weight 10 grams of crude oil .

3- put the sample in the porcelain crucible and weight it ,then burn it in furnace at 750 degrees until the sample is completely burned for 15 minutes

4-We wait for the porcelain crucible to cool and weigh it.

Calculation

$W_1 = M_1 - M_2$ where W_1 = weight of ash

M_2 = weight of porcelain crucible empty

M_1 = weight of porcelain crucible after burning

Ash % = W_1 weight of ash / W_2 weight of sample (crude oil) *100%

Discussion

1 – what is the ash content ?

2- what is the purpose of calculation the ash content ?

3- what is the effects of ash content on crude oil ?

EXPERIMENT NO 4

Name of experiment

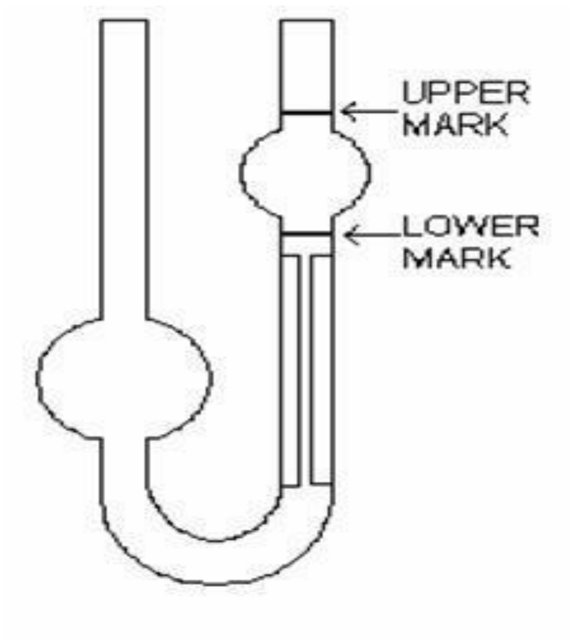
the Viscosity of crude oil and its derivatives

The objective of experiment

To measure the Viscosity of crude oil and its derivatives

Theory

The viscosity of liquid is a resistance to flow of a liquid. All liquids appear resistance to flow change from liquid to another, the water faster flow than glycerine, subsequently the viscosity of water less than glycerine at same temperature. Viscosity occurs as a result of contact liquid layers with each other. The viscosity is measuring by Ostwald viscometer.



The factors effect on the viscosity

1. Effect of Temperature: the temperature of the liquid fluid increases its viscosity decreases. In gases its opposite, the viscosity of the gases fluids increases as the temperature of the gas increases.

2. Molecular weight: the molecular weight of the liquid increases its viscosity increases.

3. Pressure: when increase the pressure on liquids, the viscosity increase because increase the attraction force between the molecules of liquid.

Procedure

1. Clean the viscometer by the water and dry it.

2. Put a certain amount of liquid in the large bulge viscometer and pull it by pipette until the small bulge is full.

3. Put viscometer vertically at the desired temperature.

4. Let the liquid to flow through the capillary tube with run time when the liquid reaches the mark shown on the viscometer and then stopped time when the liquid reaches the bottom mark.

5. Repeat the experiment to other liquids.

Calculation:

Calculate the viscosity by the relationships:

$$\frac{\eta_1}{\eta_2} = \frac{t_1 d_1}{t_2 d_2}$$

η_1 is viscosity of liquid 1.

η_2 is viscosity of water 0.891 poise.

t_1 flow time of liquid 1.

t_2 flow time of water.

d_1 density of liquid 1.

d_2 density of water 0.997 g/cm^3.

Discussion

1- What are the methods to measure viscosity ? what is the best method ? why ?

2- What are the factors that effect on viscosity , Explain with details ?

3- What are the error recourses in the experiment ?

4- Talk about effect the difference of viscosity in crude oil and its derivatives ?

Exp.4 Determination the Viscosity of Liquids

Theory:

The ***viscosity of liquid*** is a resistance to flow of a liquid. All liquids appear resistance to flow change from liquid to another, the water faster flow than glycerin, subsequently the viscosity of water less than glycerin at same temperature. Viscosity occurs as a result of contact liquid layers with each other. The viscosity is measuring by Ostwald viscometer.

Relative Viscosity is the ratio of the absolute viscosity of the fluid on the viscosity of water at a certain temperature.

The ***viscosity coefficient*** is force (dyne) necessary to move the layer of liquid 1 cm^2 in speed 1 cm/sec on another layer of liquid and the distance between them is 1cm.

Equation the Poisellieh :

$$\eta = t\frac{\pi r^4 f}{8vl}$$

For two liquids:

$$\frac{\eta_1}{\eta_2} = \frac{f_1 t_1}{f_2 t_2}$$

Where:

$\frac{\pi r^4}{8vl}$ is constant

When:

$$f = gdh$$

$$\therefore \frac{\eta_1}{\eta_2} = \frac{t_1 d_1}{t_2 d_2}$$

η_1 is viscosity of liquid 1.

η_2 is viscosity of liquid 2.

t_1 flow time of liquid 1.

t_2 *flow time of liquid* 2.

d_1 density of liquid 1.

d_2 *density of liquid* 2.

The factors effect on the viscosity:

1. Effect of Temperature: the temperature of the liquid fluid increases its viscosity decreases. In gases its opposite, the viscosity of the gases fluids increases as the temperature of the gas increases.
2. Molecular weight: the molecular weight of the liquid increases its viscosity increases.
3. Pressure: when increase the pressure on liquids, the viscosity increase because increase the attraction force between the molecules of liquid.

Chemicals and materials:

1- Ethanol

2- Glycerin

3- Di water

4- Baker

5- Ostawld viscometer

6- Pipet

Procedure:

1. Clean the viscometer by the water and ethanol and dry it.
2. Put a certain amount of liquid in the large bulge viscometer and pull it by pipette until the small bulge is full.
3. Put viscometer vertically in the water bath at the desired temperature.
4. Let the liquid to flow through the capillary tube with run time when the liquid reaches the mark shown on the viscometer and then stopped time when the liquid reaches the bottom mark.
5. Repeat the experiment and record the results (take average of results).
6. Repeat the experiment to other liquids.
7. Change the temperature and calculate the viscosity.

Calculation:

Calculate the viscosity by the relationships:

$$\frac{\eta_1}{\eta_2} = \frac{t_1 d_1}{t_2 d_2}$$

η_1 is viscosity of liquid 1.

η_2 is viscosity of water 0.891 poise.

t_1 flow time of liquid 1.

t_2 flow time of water.

d_1 density of liquid 1.

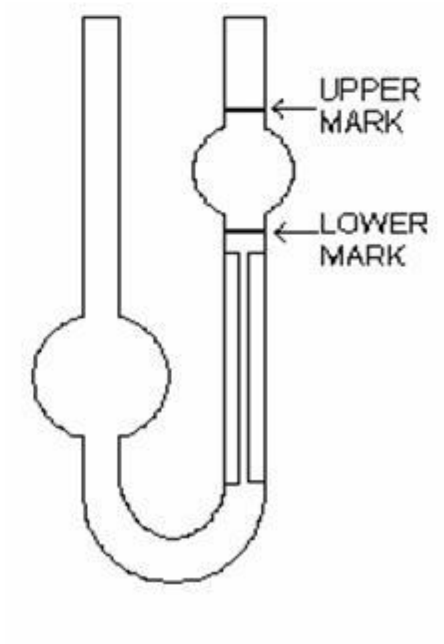
d_2 density of water 0.997 g/cm^3.

Can be calculate the Relative Viscosity by the relationships:

$$\eta_{relative} = \frac{\eta_1}{\eta_{H_2O}}$$

Liquid 1: ethanol (density of ethanol = 0.789 g/cm^3)

Temperature (C^o)	Time (Sec.)			Average time	Viscosity (poise)	Relative Viscosity
25						
30						
35						
Liquid 2: glycerin (density of glycerin = 1.261 g/cm^3)						
25						
30						
35						



Ostwald Viscometer

Experiment NO 5

Name of experiment

Drying

Objective of experiment

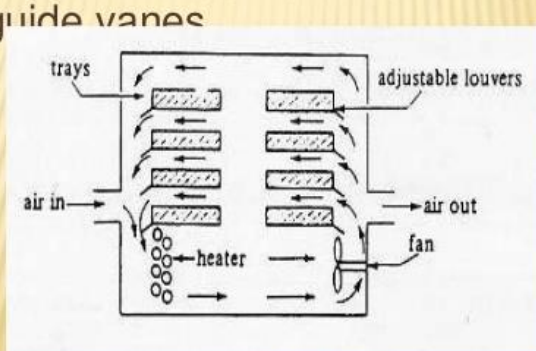
To measure the humidity content after drying process

*__Drying__ ;is a mass transfer process consisting of the removal of water or another solvent by evaporation from a solid, semi-solid or liquid. This process is often used as a final production step before selling or packaging products. To be considered "dried", the final product must be solid, in the form of a continuous sheet (e.g., paper). A source of heat and an agent to remove the vapor produced by the process are often involved. In bio products like food, grains, and pharmaceuticals like vaccines, the solvent to be removed is almost invariably water. Desiccation may be synonymous with drying or considered an extreme form of drying.

In the most common case, a gas stream, e.g., air, applies the heat by convection and carries away the vapor as humidity. Other possibilities are vacuum drying, where heat is supplied by conduction or radiation (or microwaves), while the vapor thus produced is removed by the vacuum system. Another indirect technique is drum drying where a heated surface is used to provide the energy, and aspirators draw the vapor outside the room.

TRAY DRYERS

- a batch tray dryeR consists of a stack of trays or several stacks of trays placed in a large insulated chamber in which hot air is circulated with appropriately designed fans and guide vanes



Tools used

1 – Digital balance .

2 – Beaker .

3 – Dryer .

4 – Tray .

Procedure

1 –Let the pressed steam (1-3) bar to enter the tray until it reaches to steady state .

2 – Add (20 ml water , 20 gm of sand , to get paste .

3 – Put the paste in the one tray used for drying .

4 – Put the tray in its place in the dryer and let the air at constant volumetric rate .

5 – Take the tray out of dryer , wait the tray to reduce its temperature every 10 minutes .

6 – Continue the process until the water removed from the paste.

Calculation

$$\textbf{Humidity} = \frac{\textit{weight of wet sample} - \textit{weight of dry sample}}{\textit{weight of dry sample}} * 100\ \%$$

Discussion

1 – What are the advantages and disadvantages of drying ?

2 – Why we choose the sand in our experiment ?

3 – What is the mechanism of drying ?

Basic Process Control Unit

Instruction Manual

PCT40

ISSUE 10

July 2010

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Disclaimer

Should you have any queries or comments, please contact the Armfield Customer Support helpdesk (Monday to Friday: 0800 – 1800 GMT). Contact details are as follows:

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(0) 1425 478781 (calls charged at local rate)	+44 (0) 1425 478781 (international rates apply)
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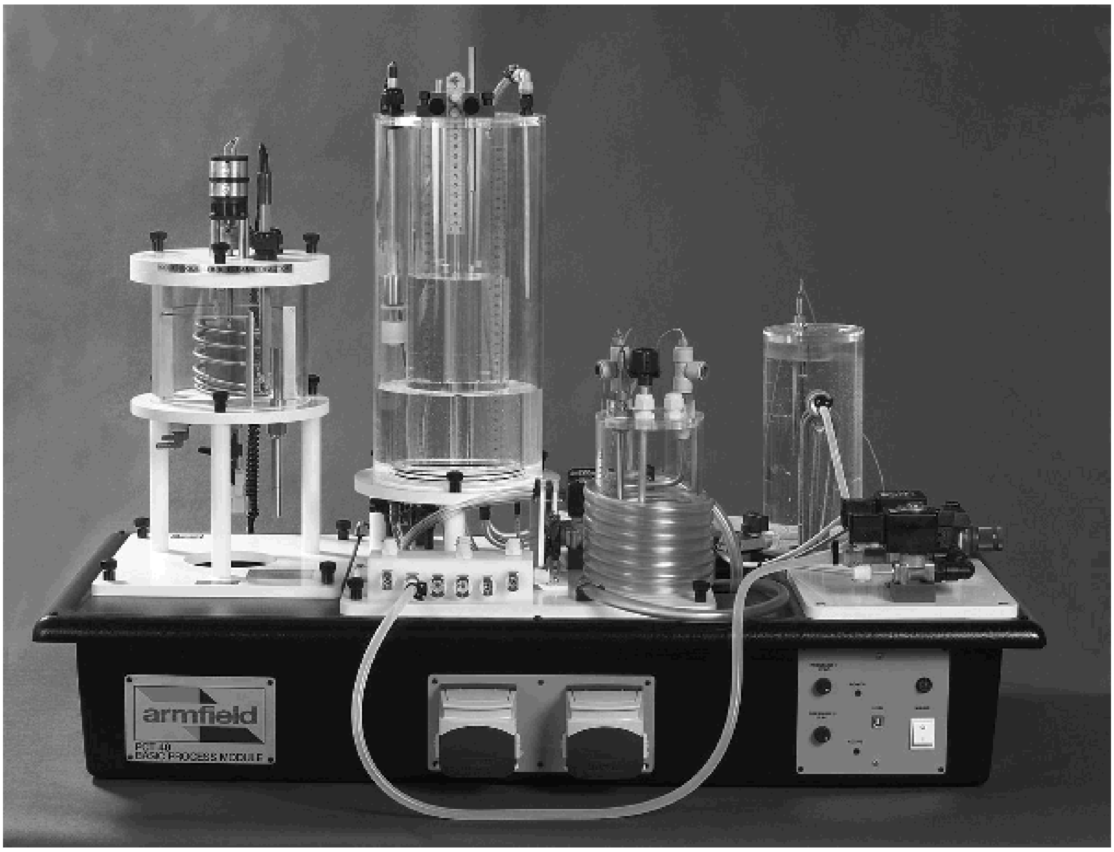
General Overview

The Armfield PCT40 system is designed for use in teaching a wide range of process control methods. The PCT40 basic unit is used under computer control to demonstrate a variety of process control loops. Processes such as level control, temperature control, flow control and pressure control can all be investigated, as can manual, on/off, proportional and PID control. The software included with the unit allows the student to change the control parameters and analyse the results from different configurations.

More advanced aspects of control can be addressed by adding optional extras to the basic system. The PCT 41 expands on the capabilities of the PCT40 with a wider range of control loops and strategies, including Remote Set Points, dual loops and Fluid Property Control (using Conductivity as a representative example). All these loops are under software control.

Other accessories are available, including a pH Probe (PCT42) for use with PCT41, an Electronic Console (PCT43) with commercial PID controller that allows the PCT40 to be operated directly without the need for a PC, and a Pneumatic Valve Module (PCT44) for those wishing to implement specialised demonstrations.



PCT40 Basic Process Control Unit with PCT41 Process Vessel Accessory

Equipment Diagrams

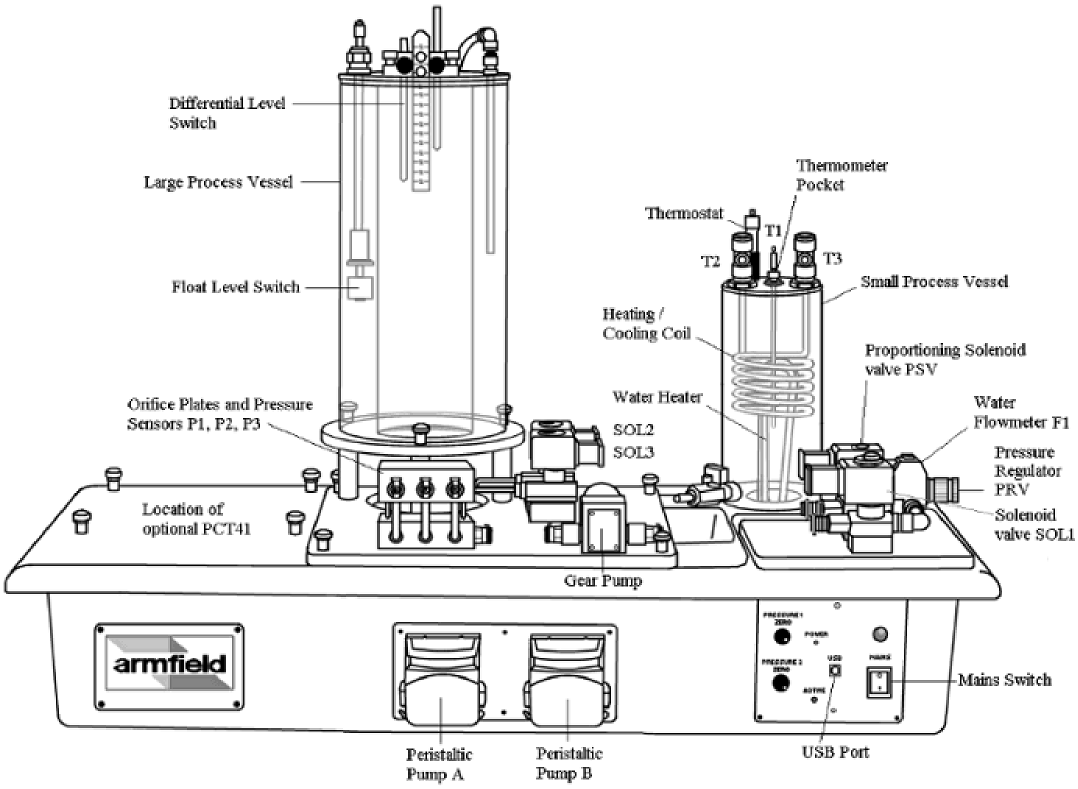


Figure 1 Front View of PCT40

Important Safety Information

Introduction

All practical work areas and laboratories should be covered by local safety regulations **which must be followed at all times**.

It is the responsibility of the owner to ensure that all users are made aware of relevant local regulations, and that the apparatus is operated in accordance with those regulations. If requested then Armfield can supply a typical set of standard laboratory safety rules, but these are guidelines only and should be modified as required. Supervision of users should be provided whenever appropriate.

Your **PCT40 Basic Process Control Unit** has been designed to be safe in use when installed, operated and maintained in accordance with the instructions in this manual. As with any piece of sophisticated equipment, dangers exist if the equipment is misused, mishandled or badly maintained.

Electrical Safety

The equipment described in this Instruction Manual operates from a mains voltage electrical supply. It must be connected to a supply of the same frequency and voltage as marked on the equipment or the mains lead. If in doubt, consult a qualified electrician or contact Armfield.

The equipment must not be operated with any of the panels removed.

To give increased operator protection, the unit incorporates a Residual Current Device (RCD), alternatively called an Earth Leakage Circuit Breaker, as an integral part of this equipment. If through misuse or accident the equipment becomes electrically dangerous, the RCD will switch off the electrical supply and reduce the severity of any electric shock received by an operator to a level which, under normal circumstances, will not cause injury to that person.

At least once each month, check that the RCD is operating correctly by pressing the TEST button. The circuit breaker **MUST** trip when the button is pressed. Failure to trip means that the operator is not protected and the equipment must be checked and repaired by a competent electrician before it is used.

Hot Surfaces and Liquids

The unit incorporates an electric heating element, and is capable of producing temperatures that could cause skin burns or scalds.

Ensure that the heating element is off when not required for the exercise being performed.

When using the heating element, before disconnecting any of the pipes or tubing:

- Stop all the pumps.
- Leave time for the water to cool
- Check that the temperature is at a safe level

Do not touch any surfaces close to ‘Hot Surfaces’ warning labels, or any of the interconnecting tubing, whilst the equipment is in use.

Chemical Safety

Details of the chemicals intended for use with this equipment are given in the Operational Procedures section. Chemicals purchased by the user are normally supplied with a COSHH data sheet which provides information on safe handling, health and safety and other issues. It is important that these guidelines are adhered to.

- It is the user's responsibility to handle chemicals safely.
- Prepare chemicals and operate the equipment in well ventilated areas.
- Only use chemicals specified in the equipment manuals and in the concentrations recommended.
- Follow local regulations regarding chemical storage and disposal.

Water Borne Hazards

The equipment described in this instruction manual involves the use of water, which under certain conditions can create a health hazard due to infection by harmful micro-organisms.

For example, the microscopic bacterium called Legionella pneumophila will feed on any scale, rust, algae or sludge in water and will breed rapidly if the temperature of water is between 20 and 45°C. Any water containing this bacterium which is sprayed or splashed creating air-borne droplets can produce a form of pneumonia called Legionnaires Disease which is potentially fatal.

Legionella is not the only harmful micro-organism which can infect water, but it serves as a useful example of the need for cleanliness.

Under the COSHH regulations, the following precautions must be observed:

- Any water contained within the product must not be allowed to stagnate, ie. the water must be changed regularly.
- Any rust, sludge, scale or algae on which micro-organisms can feed must be removed regularly, i.e. the equipment must be cleaned regularly.
- Where practicable the water should be maintained at a temperature below 20°C. If this is not practicable then the water should be disinfected if it is safe and appropriate to do so. Note that other hazards may exist in the handling of biocides used to disinfect the water.
- A scheme should be prepared for preventing or controlling the risk incorporating all of the actions listed above.

Further details on preventing infection are contained in the publication "The Control of Legionellosis including Legionnaires Disease" - Health and Safety Series booklet HS (G) 70.

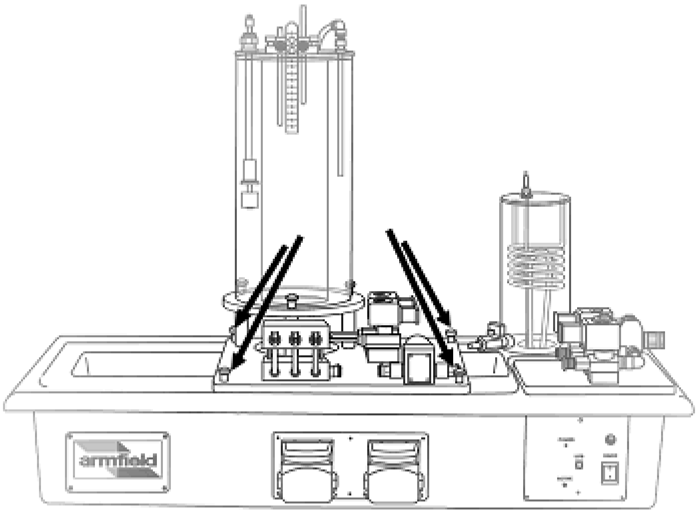
Description

Overview

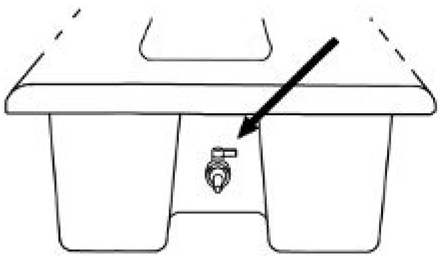
The PCT40 base unit consists of a moulded plinth, two process vessels, pumps and sensors as well as a mounting point and electrical connections for the optional PCT41 accessory.

Moulded Plinth

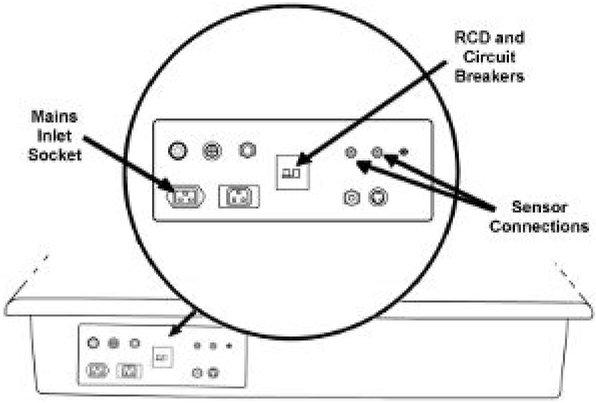
The base plate for the large process vessel is centrally located on a moulded plinth and secured using thumb nuts.



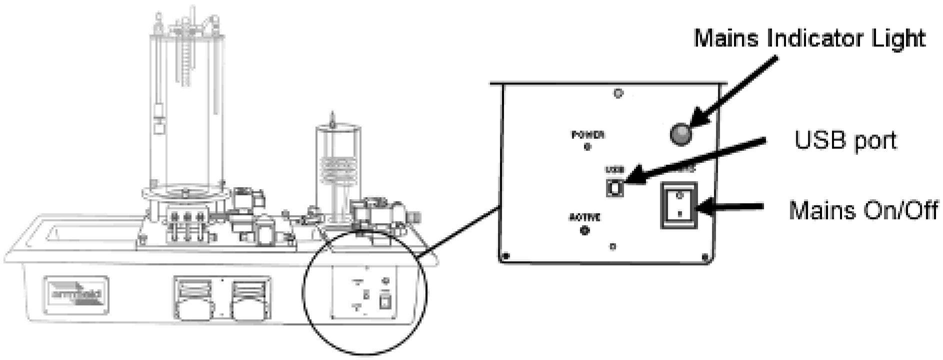
The plinth includes a drainage channel with a drain valve located at the end of the channel. The valve can be connected to a suitable drain using the flexible tubing supplied. The valve should be left open when connected to a drain



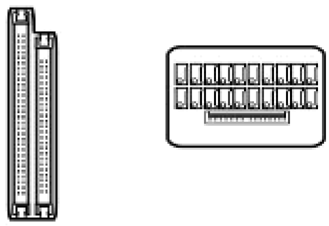
A mains power inlet socket and sensor connections are located at the rear of the plinth, which also incorporates an RCD and circuit breakers for electrical safety.



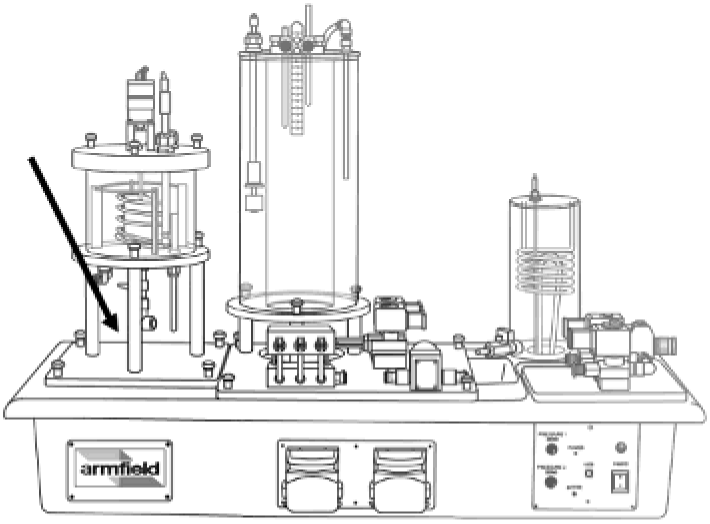
The front of the plinth incorporates the mains on/off switch and a USB socket for connection to a PC running the Armfield PCT40 software.



Both a 60-way I/O connector and a 50-way I/O connector are located on the right hand end of the plinth and may be used for connecting the PCT43 Electronic Console, when required.

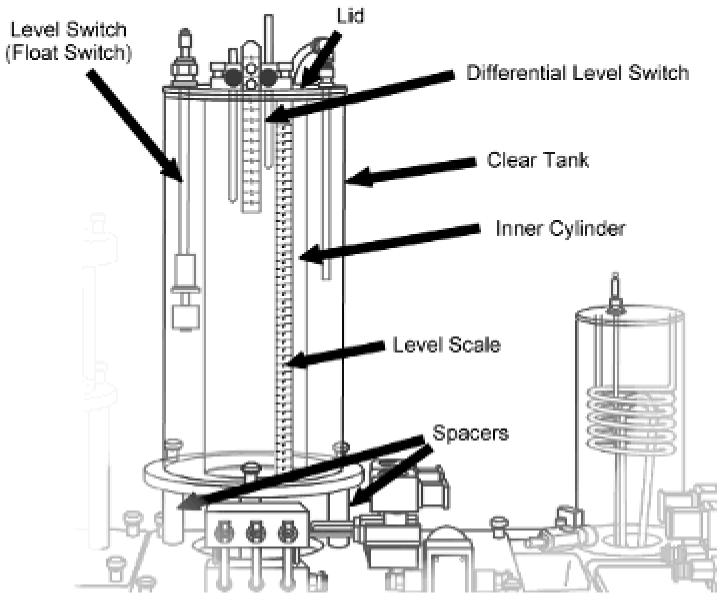


The left-hand end of the plinth includes a mounting point for the optional PCT41 Process Vessel Accessory.

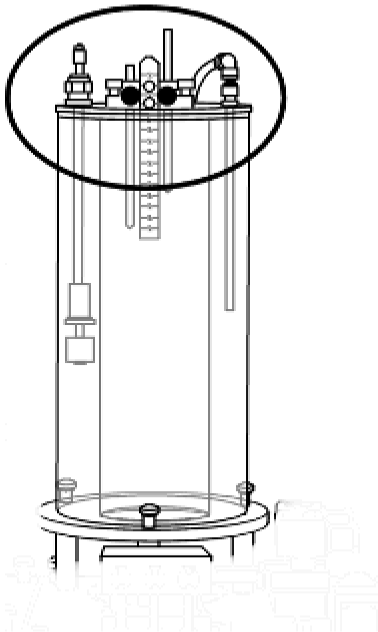


Other options such as the PCT44 Pneumatic Control Valve and PCT43 Electronic Console are designed to stand alongside the plinth when in use.

Large Process Vessel



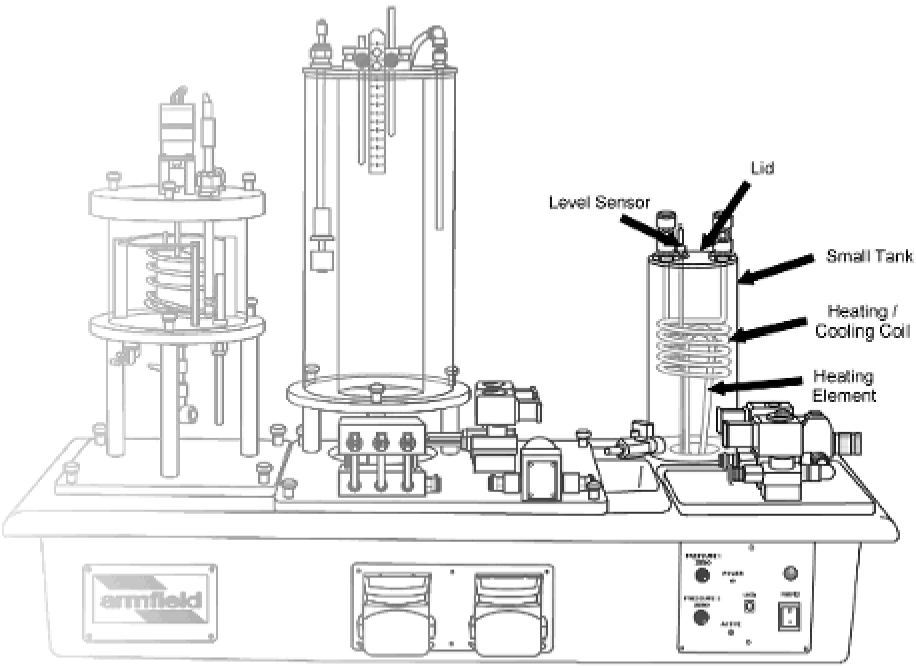
The large acrylic vessel has a removable tube inside to vary the volume of the vessel. When installed on the ‘O’ rings at the base, the tube creates an annular vessel of reduced volume. The vessel is mounted on spacers to allow access to the connections on the underside. The vessel includes a level scale. Tappings in the base of the vessel allow connections to pressure sensors, solenoid valves and pumps. A vertical overflow tube is included as a safety feature.



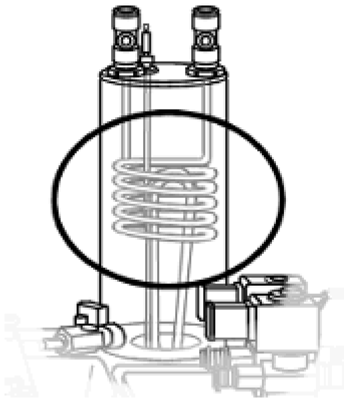
The lid of the vessel supports an adjustable height level switch, a differential level switch and a dip tube for filling or draining the vessel from the top using one of the pumps or control valves.

Small Process Vessel (Hot Water Tank)

The base unit includes a small clear acrylic process vessel at the rear. This vessel incorporates an electrical element for heating water. A thermostat and level detector are incorporated in the vessel to prevent the heater from operating if the water is too hot or the level in the vessel is too low. These safety devices are fixed and cannot be used for experimental purposes. The inlet and outlet on the side of the vessel have quick-release fittings. The vessel lid provides support for the heating/cooling coil.

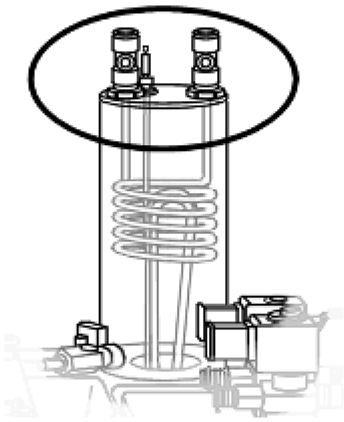


Heating/Coiling Coil

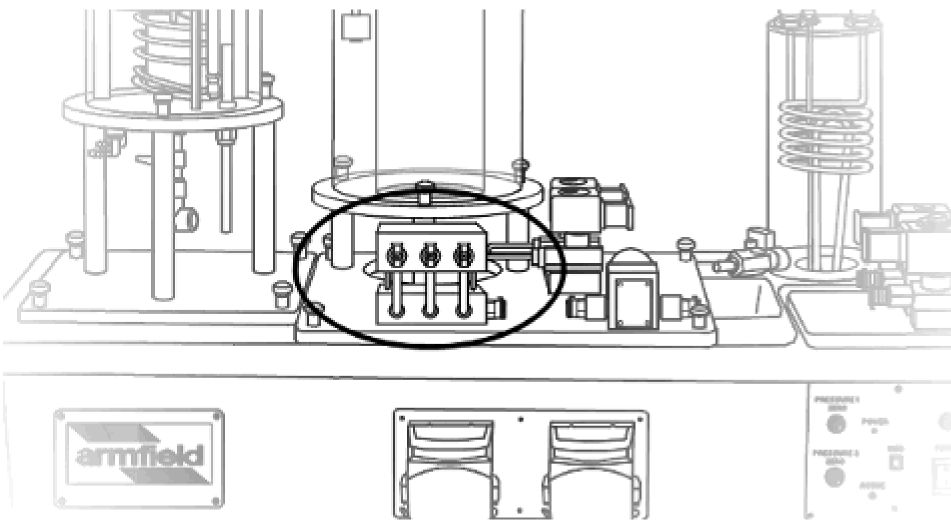


This is a stainless steel coil mounted on a lid that is designed to fit inside the small process vessel around heating element. Fittings at the inlet and outlet of the coil accommodate thermocouple-type temperature sensors and allow connection to the water supply.

The lid accommodates adjustable glands for a variable-height thermocouple sensor T1, a thermometer pocket and a temperature switch (thermostat). A spare gland allows an additional thermometer (not supplied) to be inserted into the vessel for the purpose of calibration.



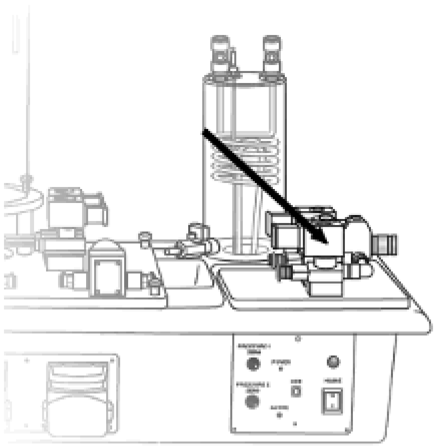
Manifold Block with Orifices and Pressure Tappings



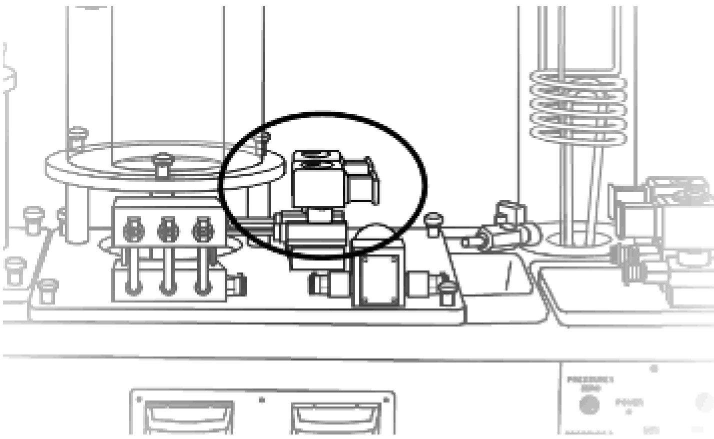
The manifold block incorporates three orifices with associated differential pressure sensors that can be used to measure flowrate The orifice associated with pressure sensors P1 and P2 is 1.9 mm diameter and suited to the low flow rates used in the PCT41 Process Vessel Accessory. In use the tube from the peristaltic pump is connected to the small quick release fitting at the front and the tube from the Process Vessel is connected to the ferrule at the rear so that the fluid flowing to the reactor vessel passes through the orifice.

The orifice associated with P3 is 3.7 mm diameter and suited to the higher flowrates used on PCT40. Fluid enters the orifice via a large quick release connector on the front of the block and exits via a Guest push fitting at the rear. An additional large quick release fitting (sealed) at the side of the block allows the flow from both peristaltic pumps to be combined before it passes through the orifice. The downstream connection from the orifice to P3 incorporates an in-line quick release connector. In normal use this is connected to give differential pressure that is related to flow. Alternatively the connection can be broken, with the sensor vented to atmosphere to allow line pressure to be measured.

Process valves SOL 1, 2 and 3

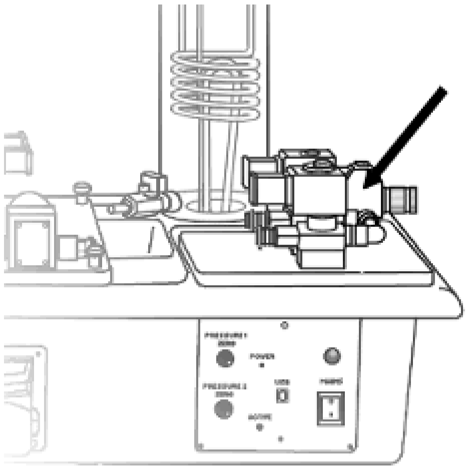


A Normally Closed solenoid valve, SOL 1, is located in front of the Proportioning Solenoid Valve for use in on/off control exercises.



Two Normally Closed solenoid valves, SOL 2 and SOL3, are fitted beneath the large process vessel. The outlet of both valves can be connected to a suitable drain using the flexible tubing supplied.

Pressure Regulator (PRV)

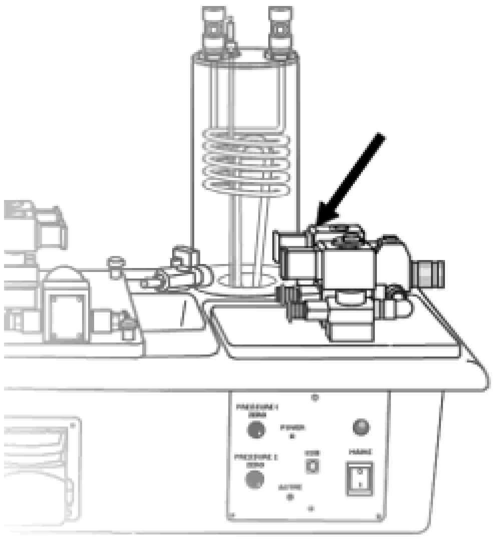


The mains water inlet is connected to a pressure regulating value with integral filter. The flow of water through the equipment can be varied by adjusting the setting of the regulator.

Inlet Flow Meter F1

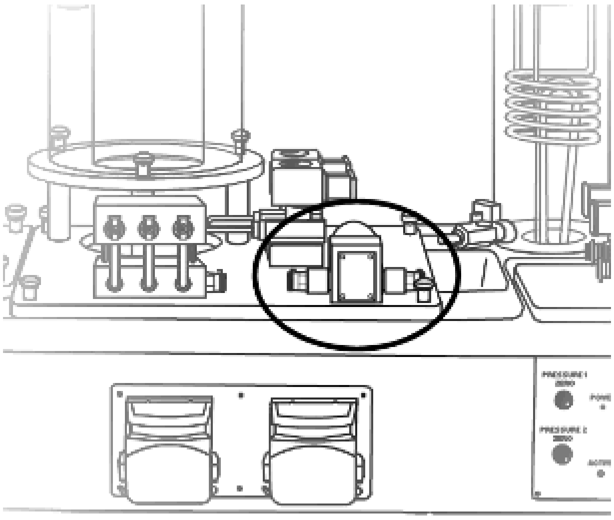
A turbine type flow meter is fitted in series with the mains water inlet to allow inlet flow rate measurement. The flow meter has a range of 0 to 1.5 litres/minute.

Proportioning Solenoid Valve PSV



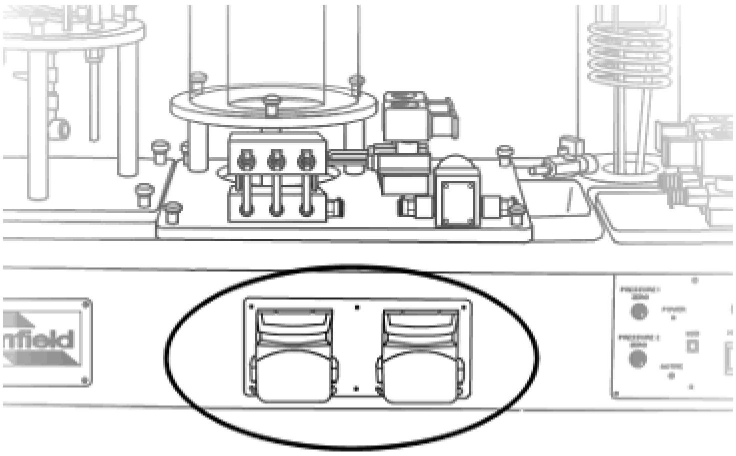
A proportioning solenoid valve is located near the mains water inlet. This is used in some process control exercises to demonstrate proportional control. At other times it may be used to regulate the inlet flow rate.

Gear Pump



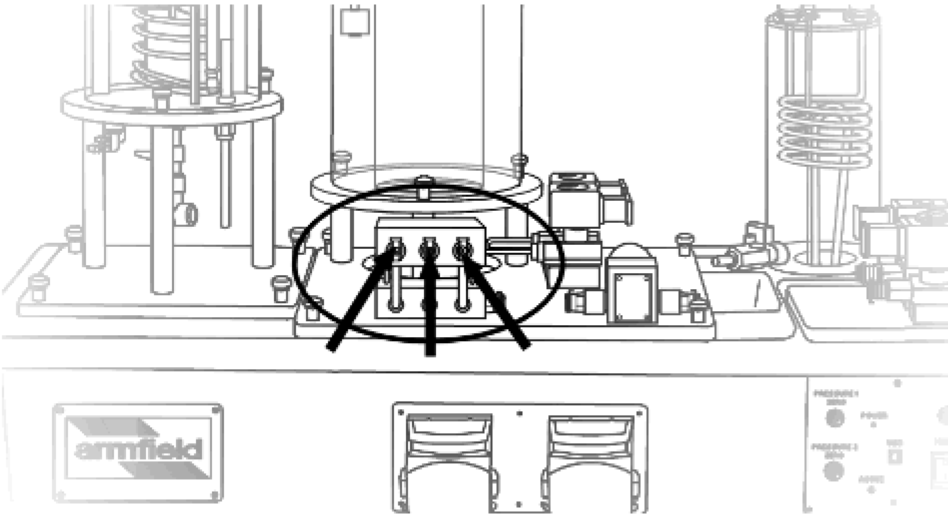
A DC motor-driven pump is located at the front of the plinth. This pump is used to pump hot water during heating and temperature control experiments.

Peristaltic Pumps A & B



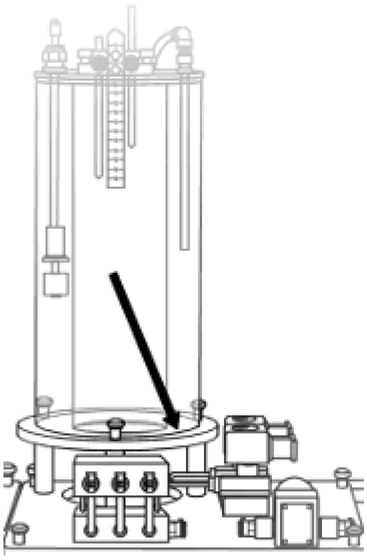
Two identical peristaltic pumps are located on the front of the plinth. These can take a wide range of silicone tubing, examples of which are included with the apparatus. The pumps may be operated individually or in parallel according to the control exercise. Pump A is located on the left-hand side, Pump B is located on the right-hand side.

Differential Pressure Sensors P1, P2 & P3



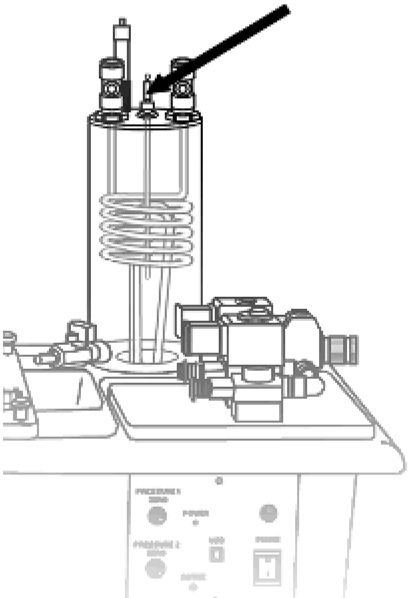
Three piezoelectric differential pressure sensors are located within the bottom section of the manifold block. Each is connected to read the differential pressure across an orifice in the top section of the block. P1 and P2 are small orifices used to measure the small flowrates associated with the optional PCT41. P3 is a large orifice for use with PCT40.

Level Sensor L1



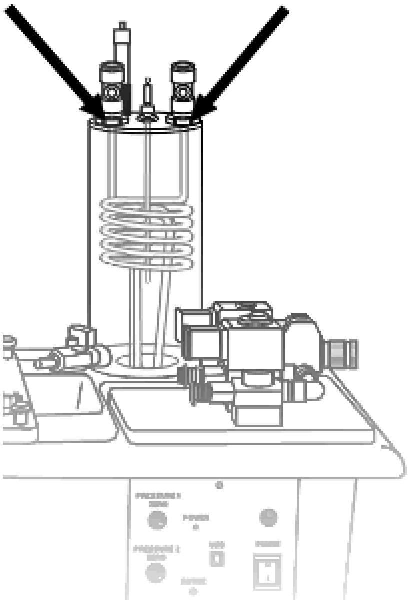
A piezoelectric pressure sensor is mounted in the base of the large process vessel. One side is connected to the inside of the process vessel, and the other is open to atmosphere, allowing the pressure in the process vessel to be measured relative to atmosphere. This sensor therefore measures the level of water in the vessel.

Temperature Sensor T1



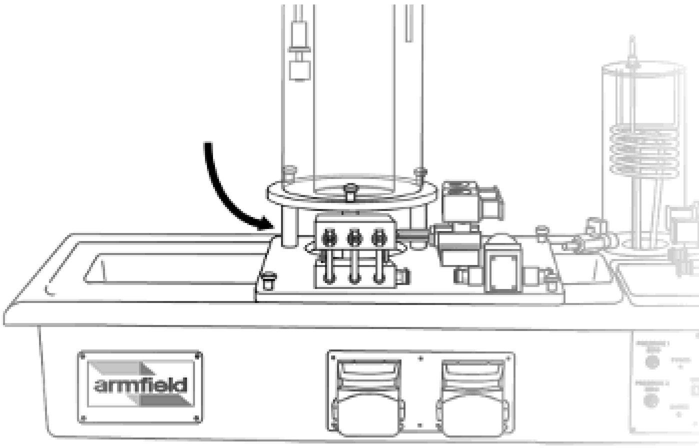
A type k thermocouple temperature probe mounted with the heating/cooling coil in the small process vessel. This probe is used to measure the fluid temperature inside the small process vessel.

Temperature Sensors T2 & T3



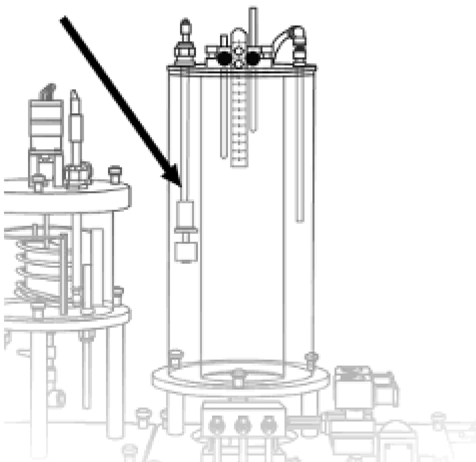
Two type K thermocouples located at the inlet and the outlet of the heating/cooling coil. These are used to measure the temperature of the fluid as it enters and leaves the coil.

Temperature Sensor T4



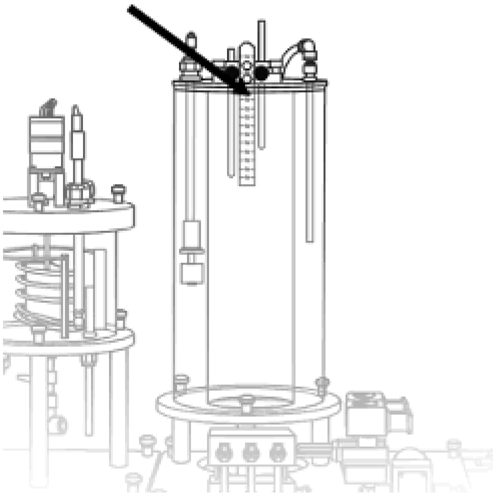
A type K thermocouple is located near the back of the base plate to the left of the large process vessel. This sensor is used during experiments utilising a holding tube, to measure fluid temperature at the outlet of the holding tube. This sensor is also used to measure temperature inside the reactor of the optional PCT41.

Level Switch



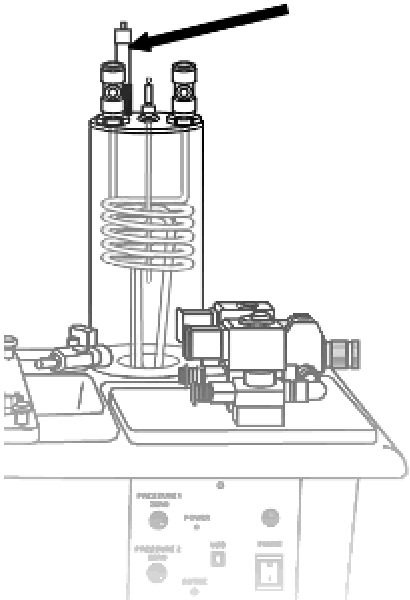
A height-adjustable fixed dead-band float switch.

Differential Level Switch



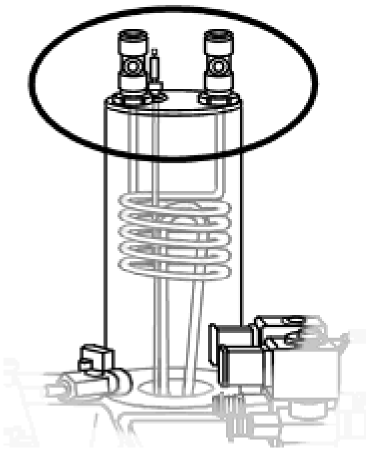
A variable dead-band conductive level switch consisting of fixed earth rod and adjustable high / low level electrodes on a support.

Thermostat (Temperature switch)



A fixed dead-band temperature switch consisting of a rod thermostat with adjustable set point.

Thermometer Pocket



A stainless steel thermometer pocket is located in the lid of the small process vessel. This slows the response of thermocouple T1 when it is inserted into the pocket.

Software

The PCT40 is supplied with an educational software package with a wide range of facilities and functions. The computer is the primary interface between the user and the equipment. The software displays real time process mimic diagrams with readings of the relevant sensor outputs and controls for the system inputs. Manual, On/off, time proportioned and PID control loops can be configured using ten predetermined student exercises.

All control and sensor signals can be logged continuously using the PC, and disturbances of known magnitude can be introduced. This eliminates the need for a separate process recorder or chart recorder for analysis of the process control responses. This software is compatible with PCs using Microsoft Windows™ 98, 2000 and XP. The computer communicates to the PCT40 using a standard universal serial bus (USB) interface. Installation instructions are printed on the label of the software CD provided with the equipment. The software includes a comprehensive online Help Text.

The software also includes a driver to allow the users to write their own Labview software. (**Note:** Armfield only provide the driver, NOT the Labview software).

Installation

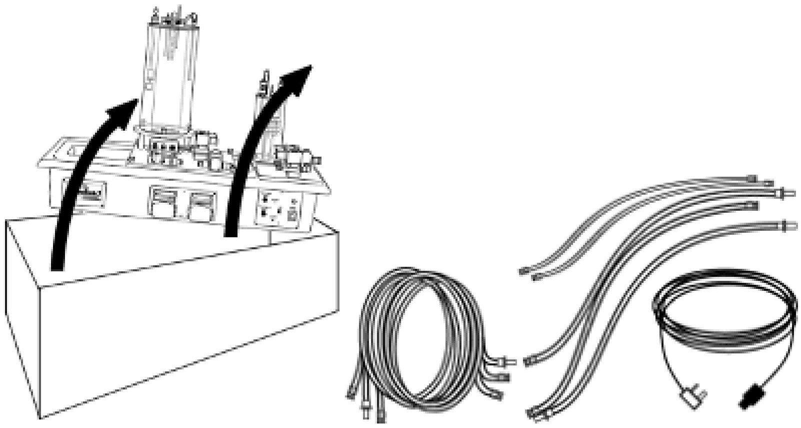
Advisory

Before operating the equipment, it must be unpacked, assembled and installed as described in the steps that follow. Safe use of the equipment depends on following the correct installation procedure.

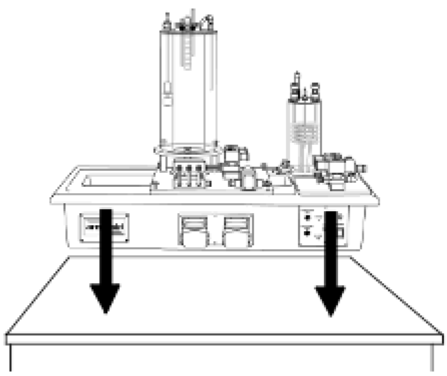
Installation Process

To install the equipment:

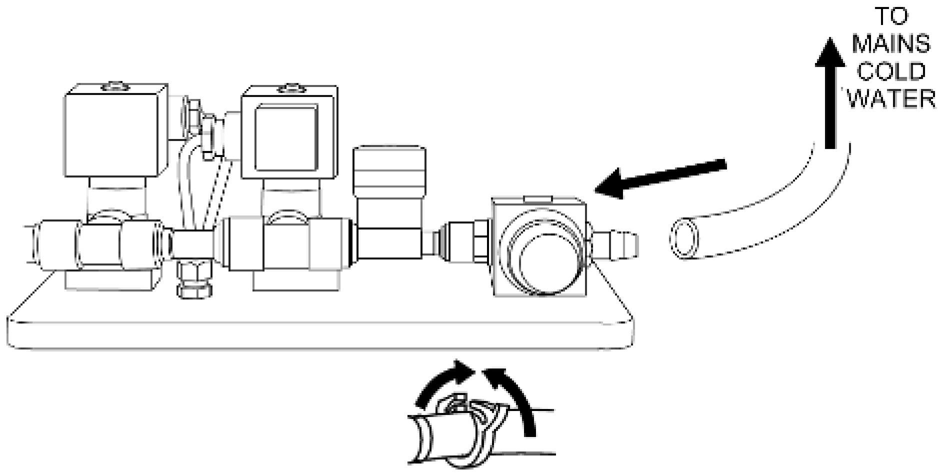
1. Take the PCT40 unit out of its packing box and remove all packaging. Retain all leads and tubing.



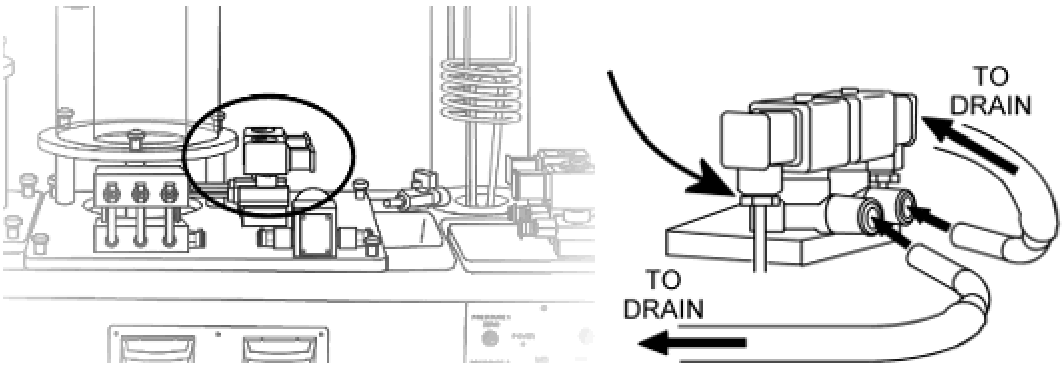
2. Place the PCT40 on a firm, level bench top or table.



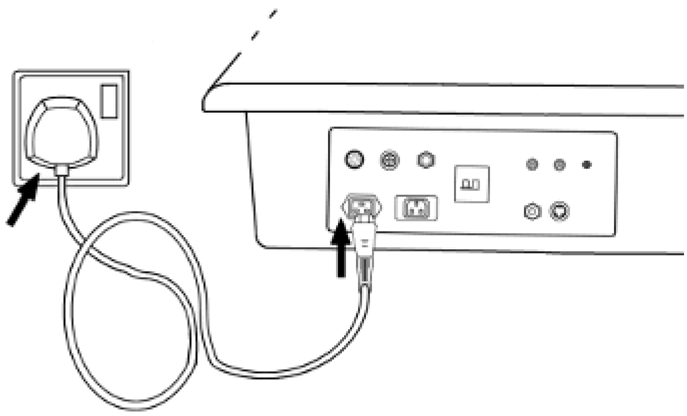
3. Connect the inlet to a supply of cold water using a standard ½" / 12.5mm length of standard hose (not supplied by Armfield), and secure using a suitable clip (not supplied).



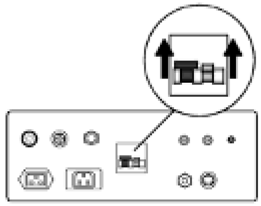
4. Connect the tubing supplied with right-angle (90°) Guest push fittings to the valves SOL2 and SOL3 beside the large process vessel.



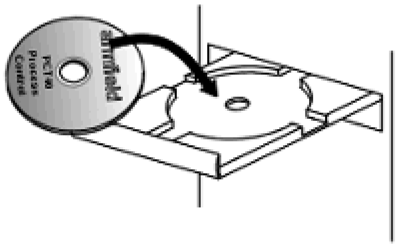
5. Use the electrical cable provided, connect the power socket at the rear of the plinth to a suitable mains electricity supply.



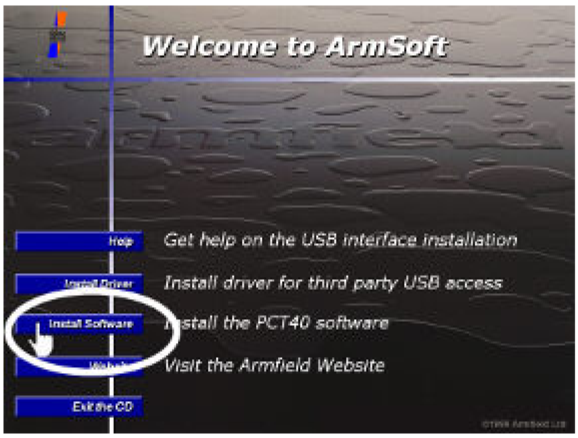
6. Check that the RCD and circuit breakers at the back of the equipment are in the ON (up) position:

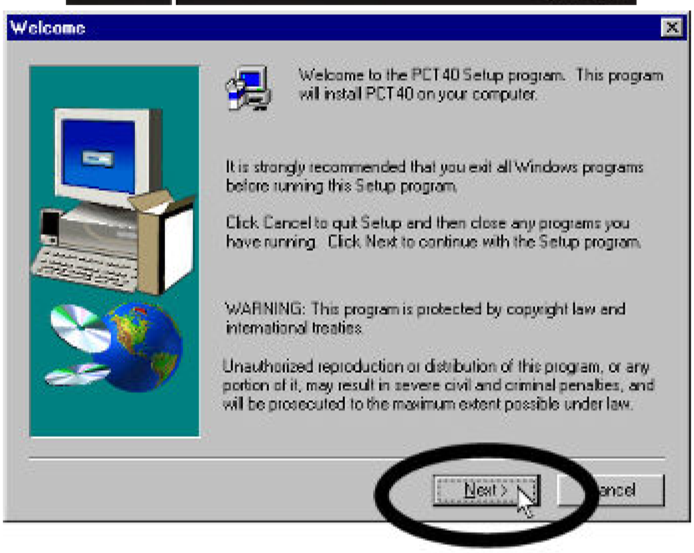


7.

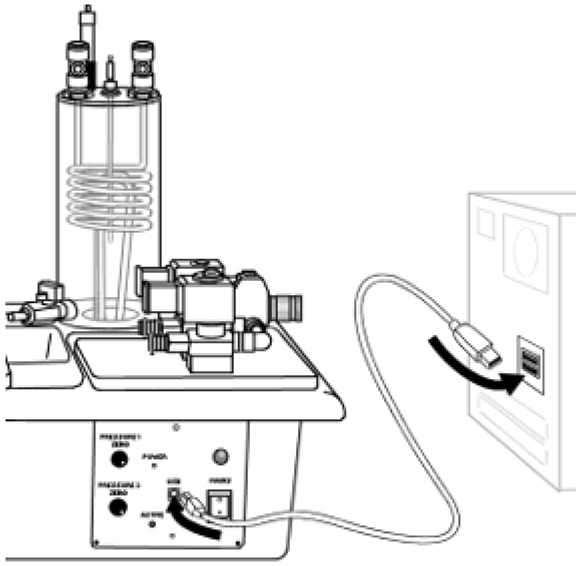


Insert the PCT40 software CD-ROM into the CD-R drive of a suitable PC. The installation program should autorun. If it does not, select ‘Run...’ from your Start menu, type run d:\setup where d is the letter of your CD-ROM drive. Follow the instructions on screen.

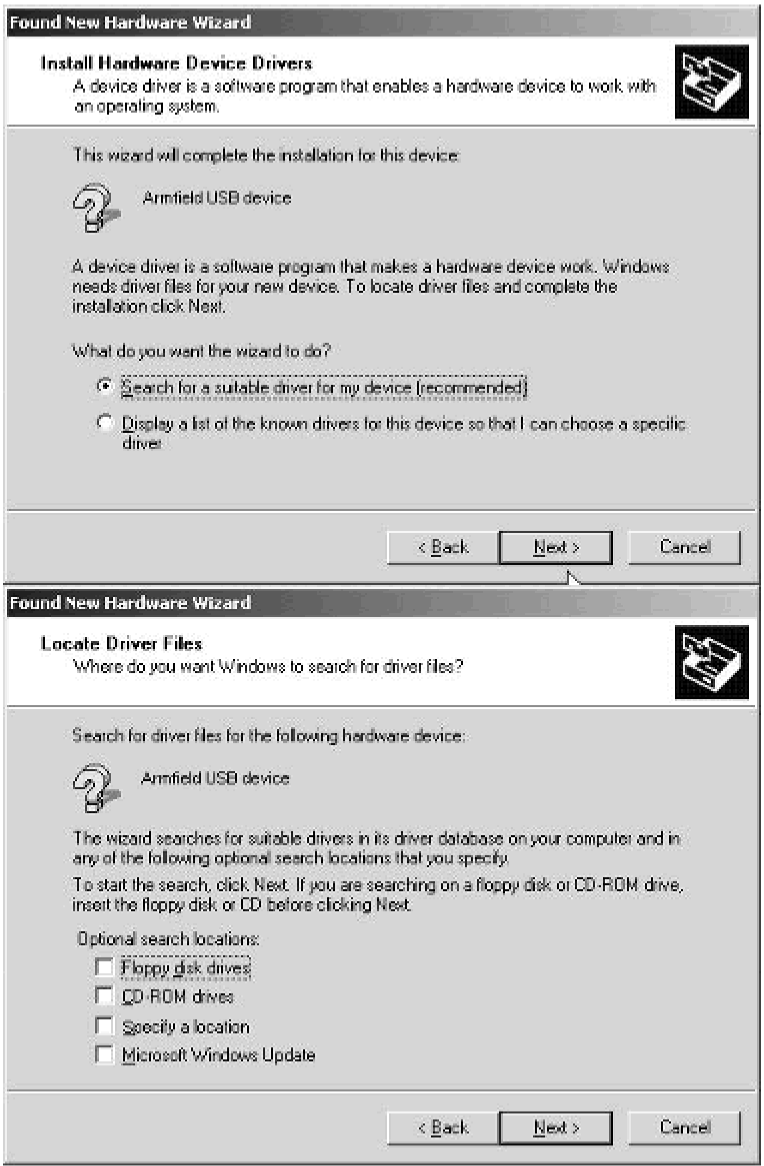




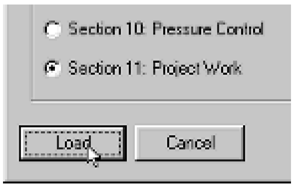
8. Connect the PCT40 to the PC. using the USB cable supplied.



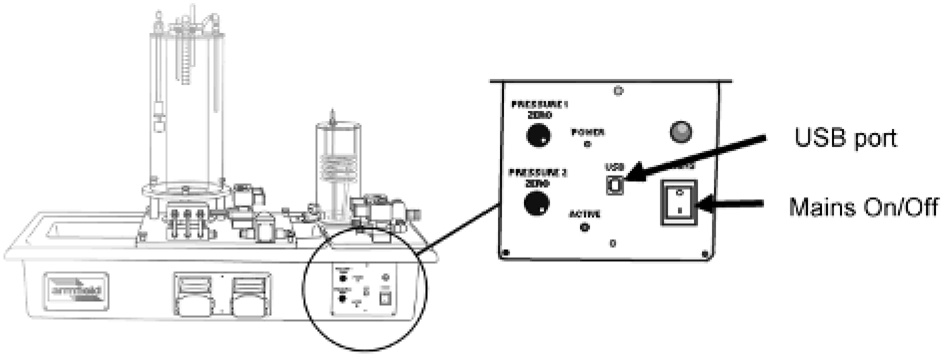
9. The computer should automatically detect the USB interface device. Follow the instructions to install the correct driver:



10. Run the PCT40 software and select the Project Work exercise.

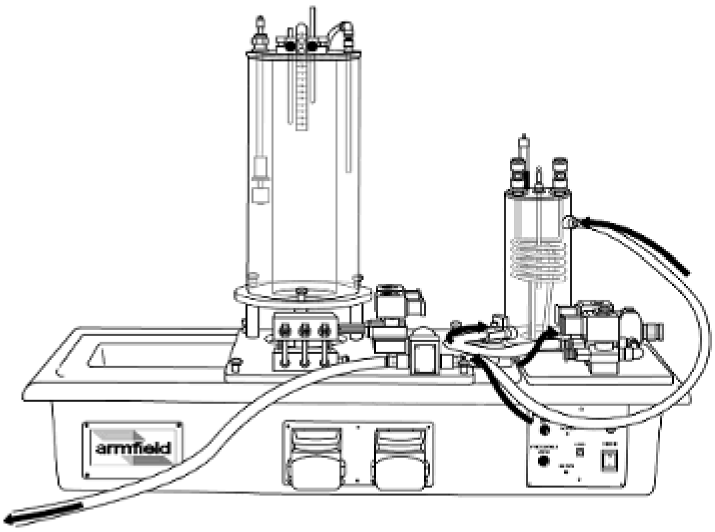


11. The on/off switch for the apparatus is located on the orange panel on the front of the plinth. Switch on the apparatus.

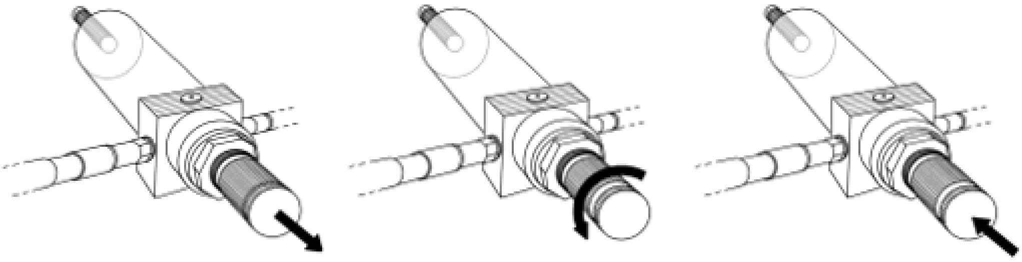


NOTE: The red and green LCD indicators on the front of the plinth are associated with the USB connection to the PC. These may be lit even if the PCT40 unit itself is switched off.

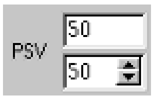
12. Using the flexible tubing provided, plumb the system as shown to allow testing of the apparatus.



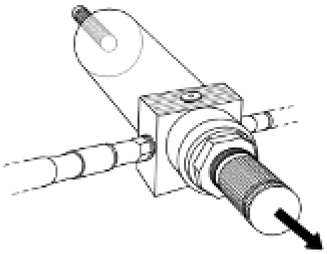
13. Close the pressure regulator: pull the grey knob away from the body of the regulator, turn the knob fully anticlockwise, then push the knob back in.



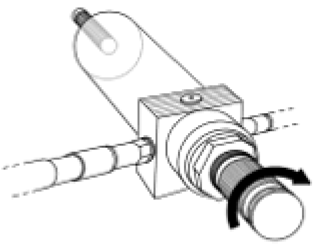
14. Open the PSV valve by typing a value of 50 into the display box on the software screen.

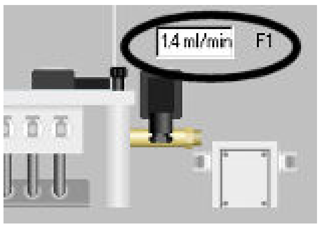


15. Pull out the grey knob on the right hand side of the regulator.

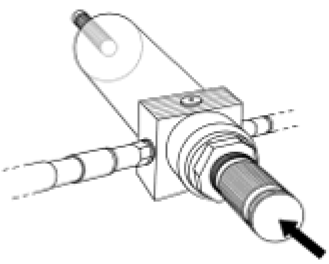


16. Turn the knob slowly in a clockwise direction (looking at end of knob) to set a flow rate of 1.4 L/min.

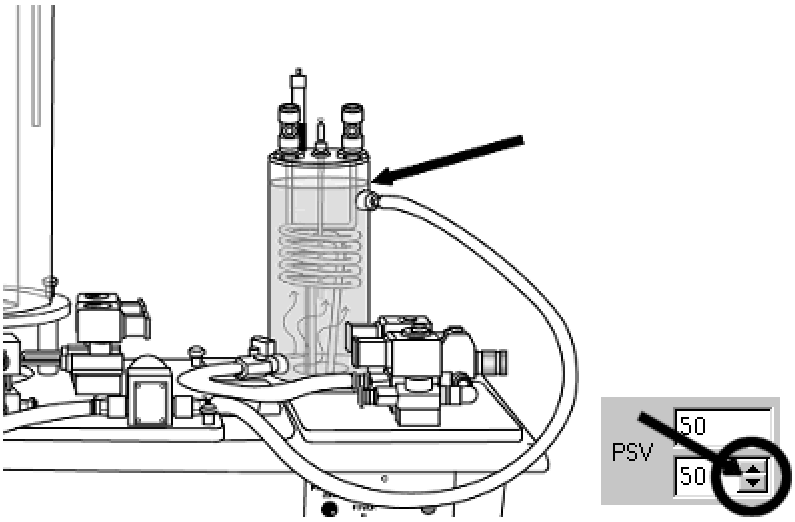




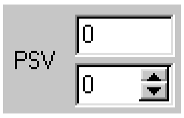
17. Lock the regulator setting by pushing the grey knob back towards the body of the regulator:



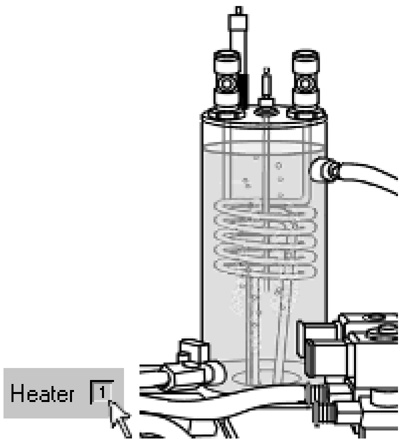
18. Alter the setting of the PSV using the arrow keys. Flow into the small process vessel should increase as the valve setting increases, and decrease as the setting decreases. After testing, set the valve to 50% until the small process vessel fills and water covers the tip of the level sensor.



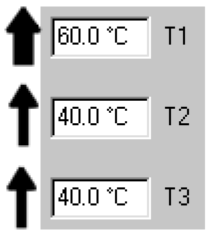
19. Close the PSV by setting it to 0%



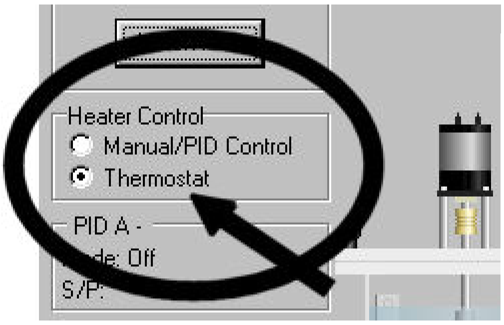
20. Switch on the heater. (SSR drive). The heater may be audible when on. Heated water will be visible as it rises from the element.

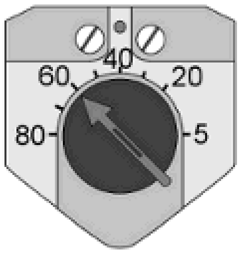


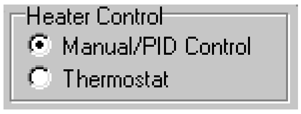
21. Check the temperature sensor readings on the software screen. T1 should increase as the temperature within the vessel rises; T2 and T3 should increase slightly as heat is conducted through the coil.



22. Set the Heater Control to ‘Thermostat’. On the top of the thermostat probe, set the control dial to 60 (°C). Check that the heater begins to operate.

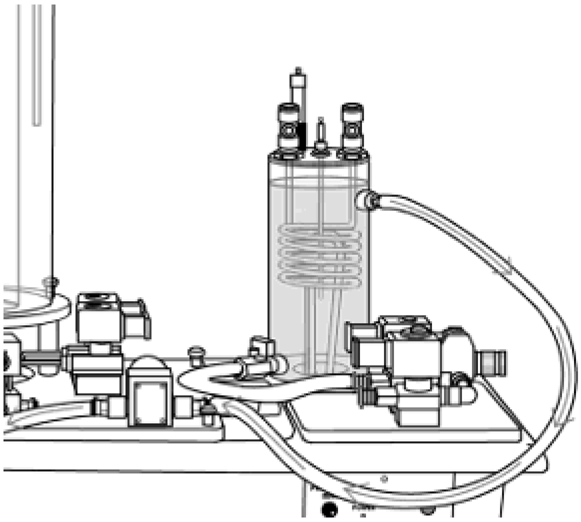




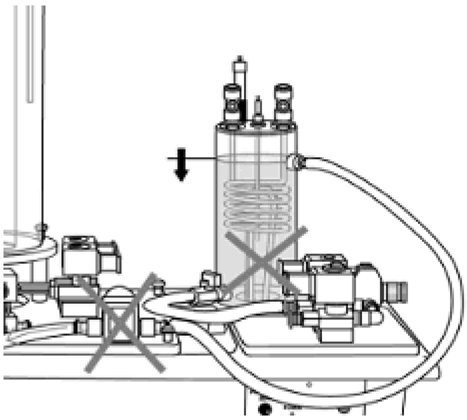


Set the Heater Control back to 'Manual/PID Control'.

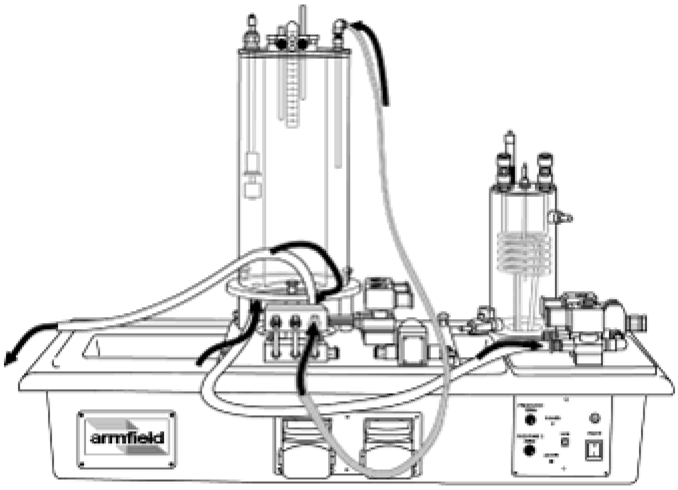
23. Set the Gear Pump Speed to 50%. The gear pump should begin to operate and water to flow from the small process vessel to drain.



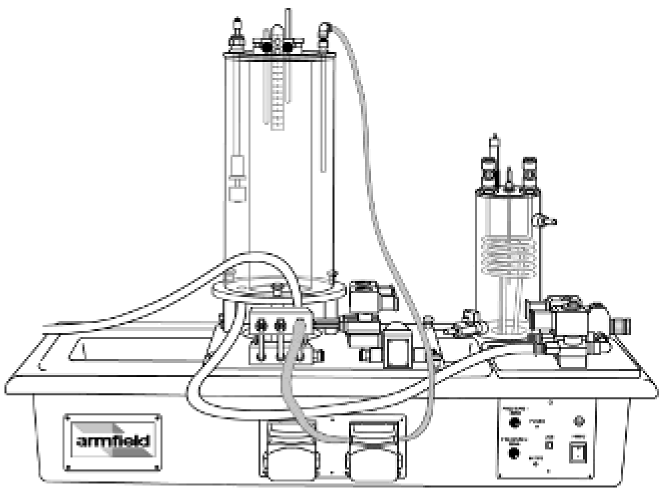
24. When the water level in the small process vessel drops below the tip of the level sensor, the gear pump and the heater should both stop working and the Level Low warning light should turn red. This shows that the safety cut-outs are working.

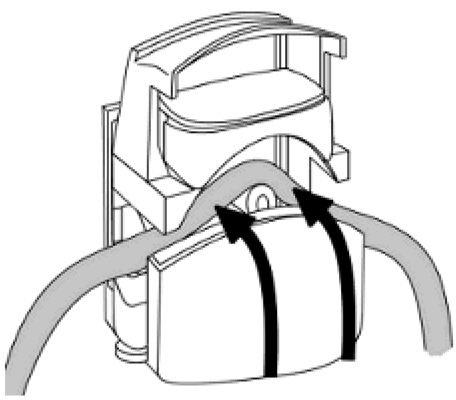


25. Change the plumbing to connect the apparatus in the following way.

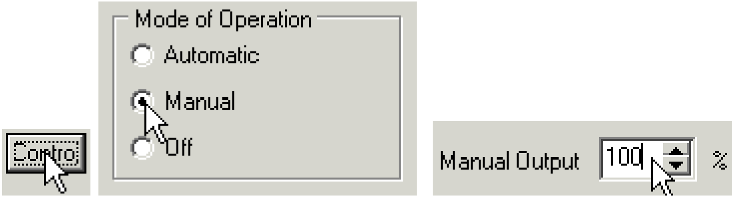


26. Insert the soft silicone tubing into the peristaltic pump as shown.

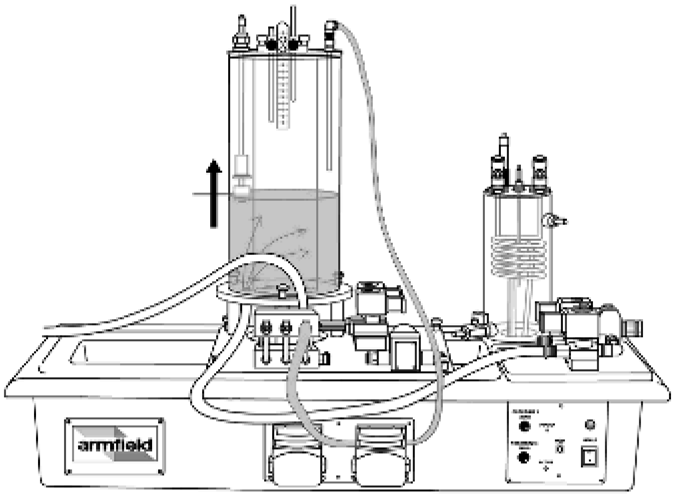




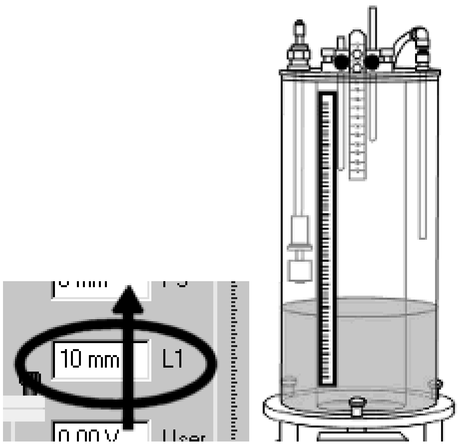
27. Open valve SOL1 by selecting the ‘Control’ button, then setting Manual control at 100%.



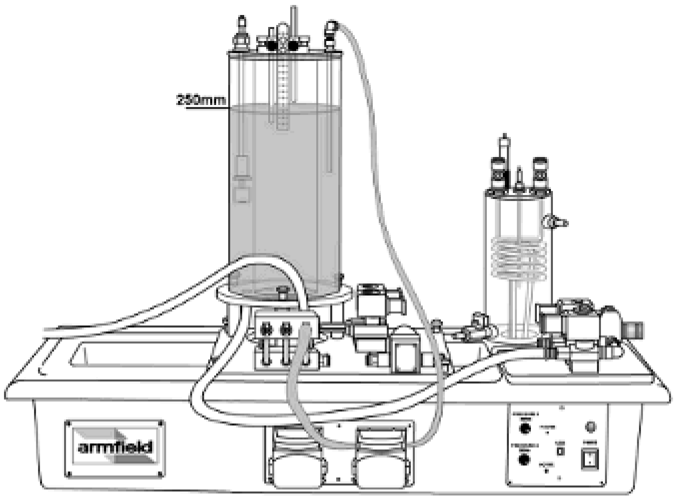
28. The large process vessel will begin to fill with water.

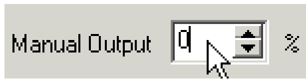


29. Observe that the level sensor reading on the software screen increases as the water level rises. The sensor output should approximately match the level reading from the gauge on the vessel side (the calibration procedure for the sensor is described in the PCT40 software Help Text).

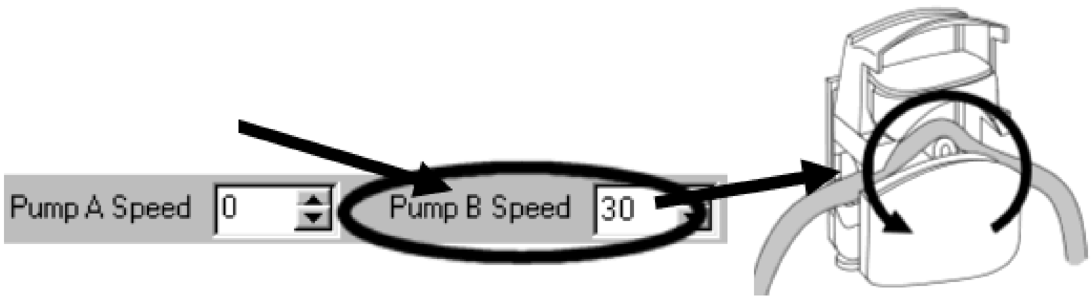


30. Allow the water in the large process vessel to reach a level of 250mm, then close the valve SOL1 by setting it back to 0%.

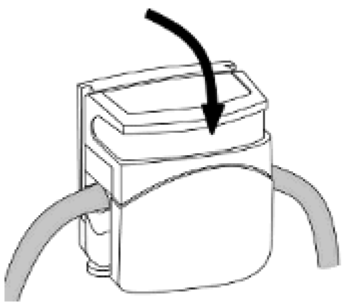


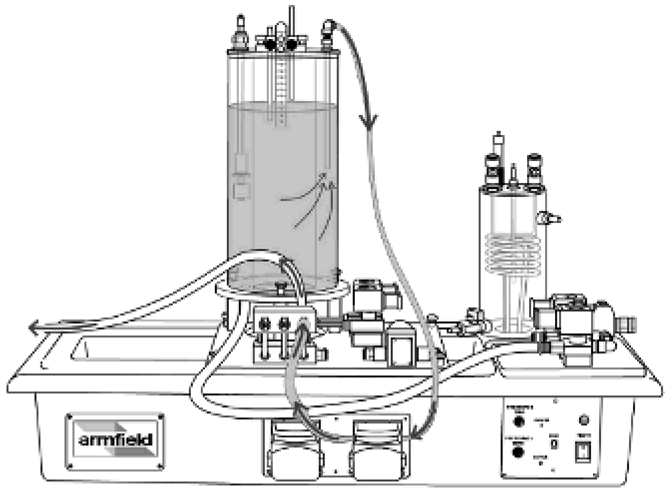


31. With the lid of the pump still open, set the speed of the pump to 30% by typing this value into the display box on the software screen. The pump should begin to operate.

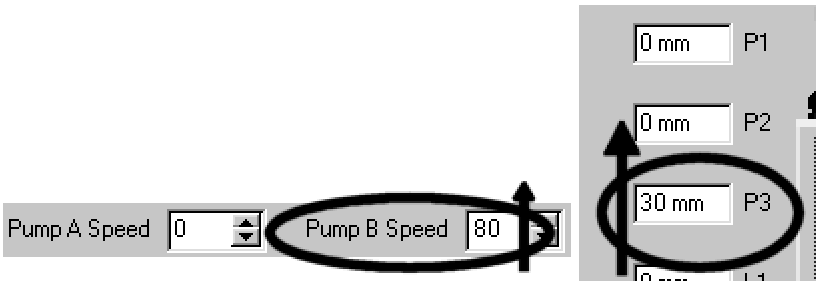


32. With the pump running, close the pump lid. Water should now be drawn along the tube from the large process vessel, through the pump and then through the differential pressure sensor set within the manifold block (in front of the large process vessel).

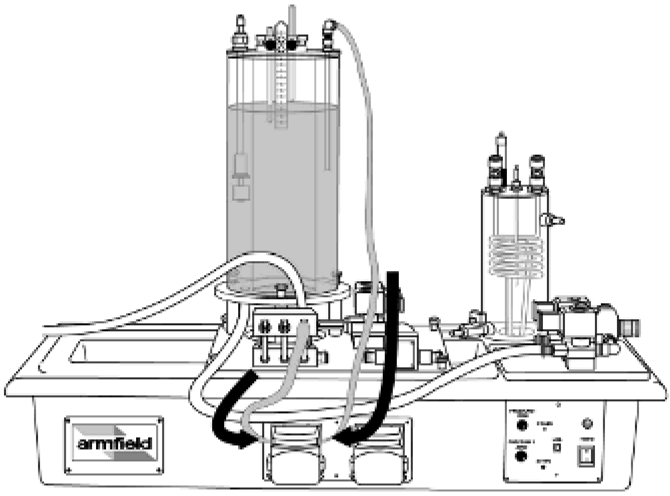




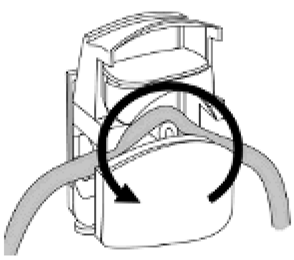
33. Check that there is a positive reading from the differential pressure sensor P3. Increase the speed of Pump B, and check that the differential pressure reading also increases. Reduce the speed of Pump A to 0.



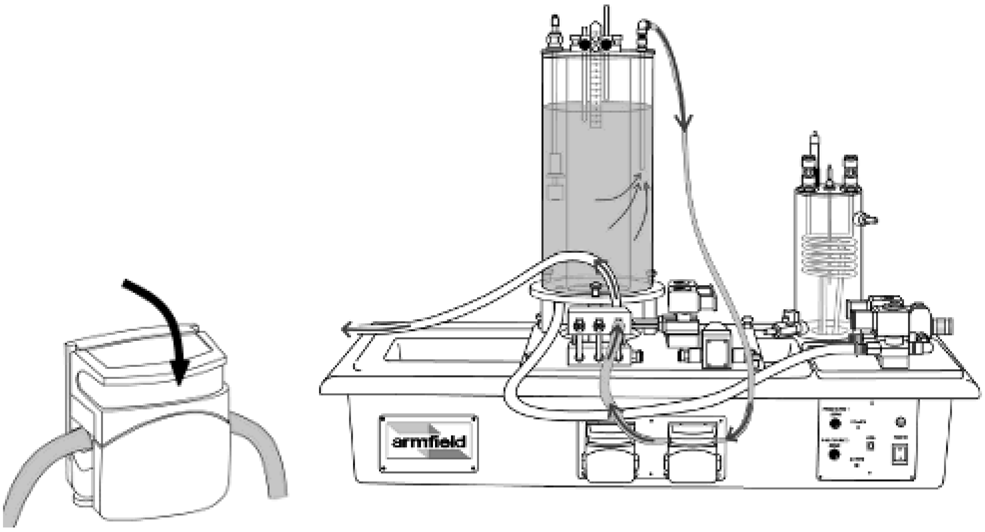
34. Open pump B, remove the tube, and transfer the tube to Pump A.



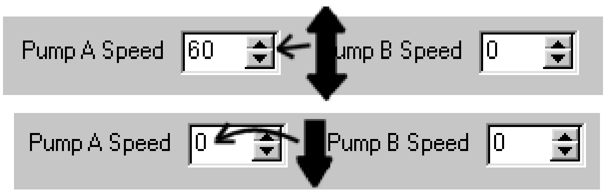
35. With Pump A open, set the speed of the pump to 30%. The pump should begin to operate.



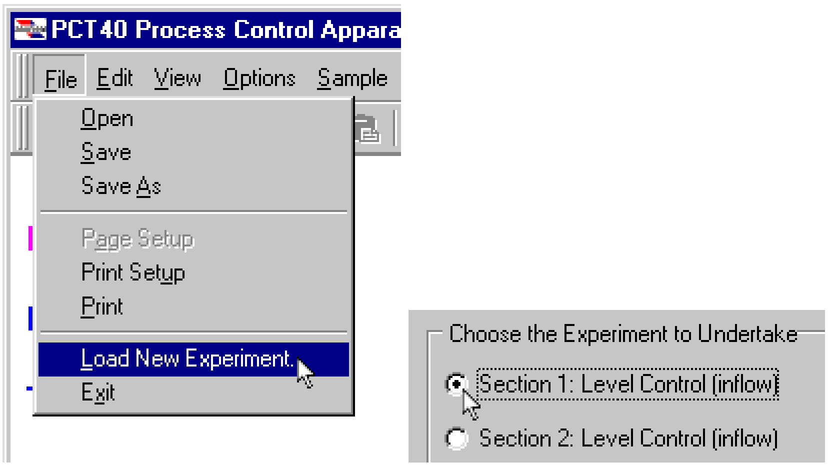
36. Close the pump lid. Water should now be drawn along the flexible tubing from the large process vessel, through Pump A and the differential pressure sensor then out to drain.



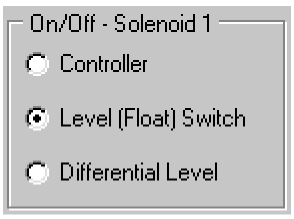
37. Vary the pump speed using the arrow keys to check that the pump is controlling correctly, then set the pump speed back to 0%.



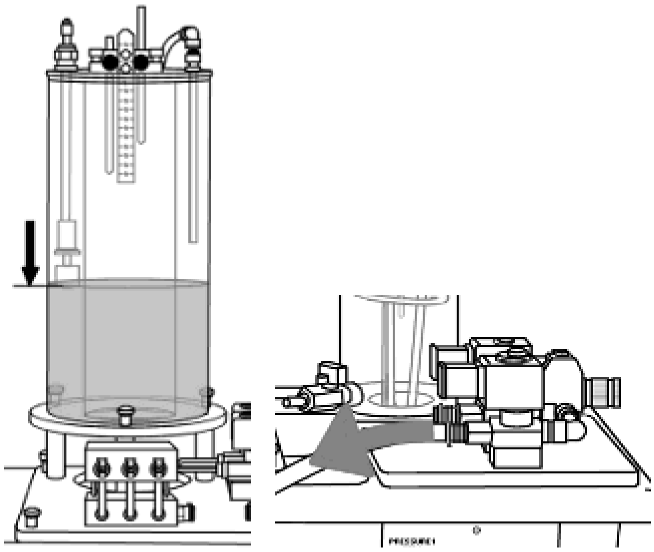
38. Select 'Load New Experiment...' from the 'File' menu, and load Exercise 1.



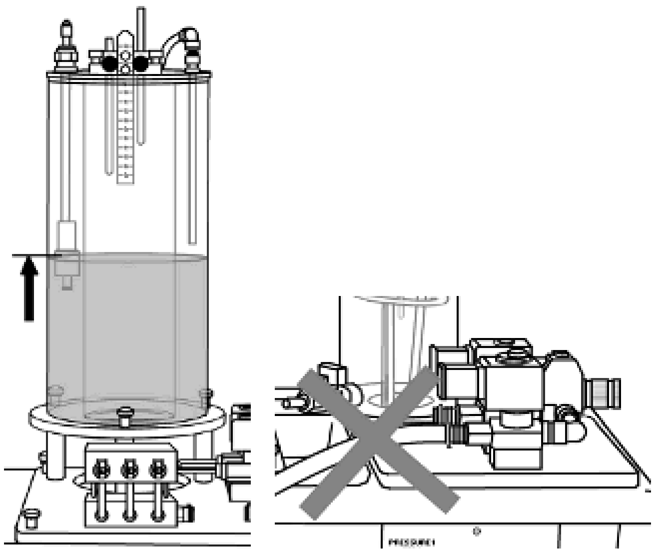
39. Set the software to control the valve SOL 1 using the Level (Float) Switch.



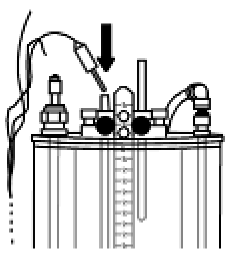
SOL1 should open when the water level in the tank drops so that the float reaches its lowest position...



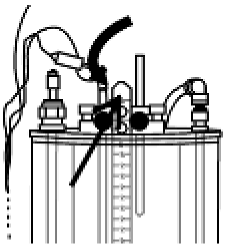
...and close when the float reaches the highest position as the water level rises once more.



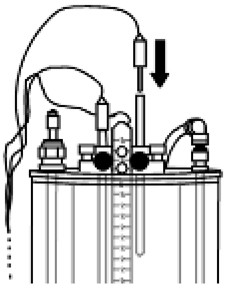
40. The blue plug (blue wire) to the top of the left-hand rod on the differential level switch, which should be positioned to give the low level setpoint.



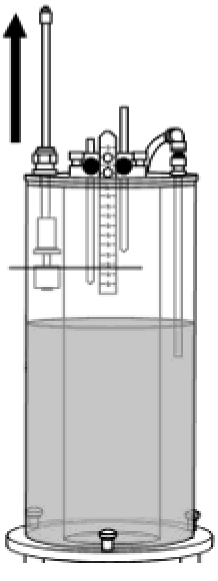
The green plug (green and yellow wire) to the socket on the back of the differential level switch (the connection behind the metal ruler).



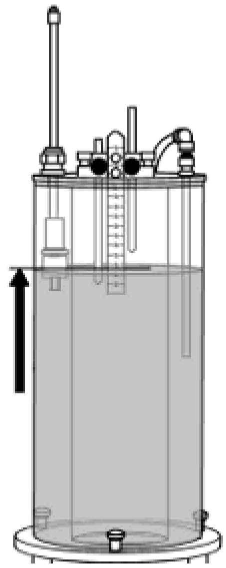
The red plug (brown wire) to the top of the right-hand rod on the differential level switch, which should be positioned to give the high level setpoint.



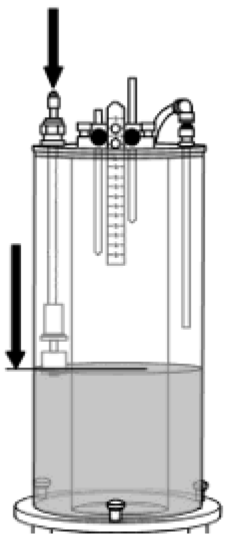
41. Adjust the level switch (float switch) until the float is higher than the lower of the two electrodes on the differential level switch.



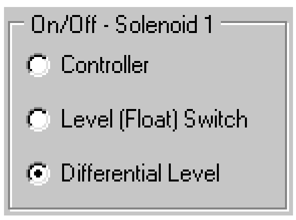
42. Allow the water level to reach the lower electrode on the differential level switch.



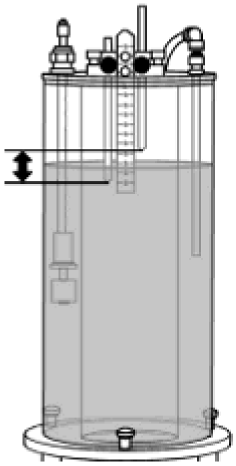
43. Lower the level switch and allow the water level in the vessel to drop to 50mm below the level of the differential level sensor.



44. Set the software to control the valve SOL1 using the Differential Level Switch.



The level in the tank should now be controlled by the differential level switch. SOL 1 should remain open until the water level in the tank reaches the higher of the two electrodes, then close until the water level reaches the lower of the two electrodes.



45. Switch the control of SOL 1 to ‘Controller’. The valve should

Your PCT40 Multifunction Process Control Unit is now installed, commissioned and ready for use. If the unit will not be used for some time, follow the procedure in Emptying Tubes with Self Sealing Ends to drain the equipment.

Ensure all users have read and understood the Important Safety Information section before operating the equipment.

Further information on the operation of the PCT40 may be found in the Operation section.

Electrical Wiring Diagram

Click on the relevant link to invoke the Wiring Diagram:

Wiring Diagram CDM29377/1

Wiring Diagram CDM29377/2

Printed Versions of this Instruction Manual

Please note, all wiring diagrams are appended at the rear of this manual

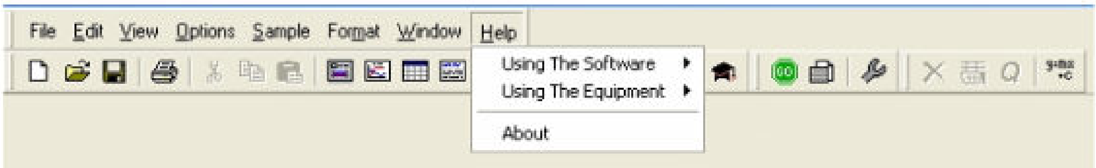
Operation

Where necessary, refer to the drawings in the Equipment Diagrams section.

Operating the Software

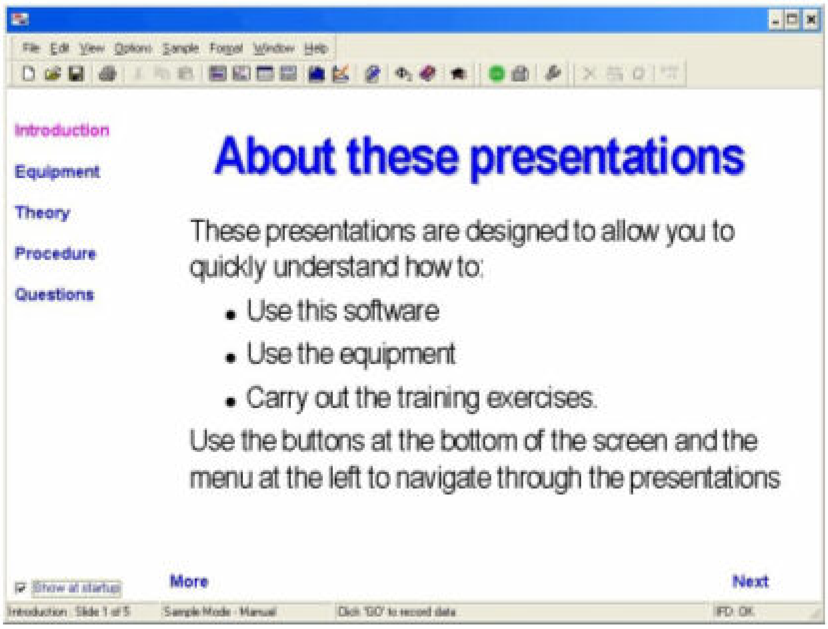
Note: The diagrams in this section are included as typical examples and may not relate specifically to the individual product described in this instruction manual.

The Armfield Software is a powerful Educational and Data Logging tool with a wide range of features. Some of the major features are highlighted below, to assist users, but full details on the software and how to use it are provided in the presentations and Help text incorporated in the Software. Help on Using the Software or Using the Equipment is available by clicking the appropriate topic in the **Help** drop-down menu from the upper toolbar when operating the software as shown:



Before operating the software ensure that the equipment has been connected to the IFD5 Interface (where IFD5 is separate from the equipment) and the IFD5 has been connected to a suitable PC using a USB lead. For further information on these actions refer to the Operation manual.

Load the software. If multiple experiments are available then a menu will be displayed listing the options. Wait for the presentation screen to open fully as shown:



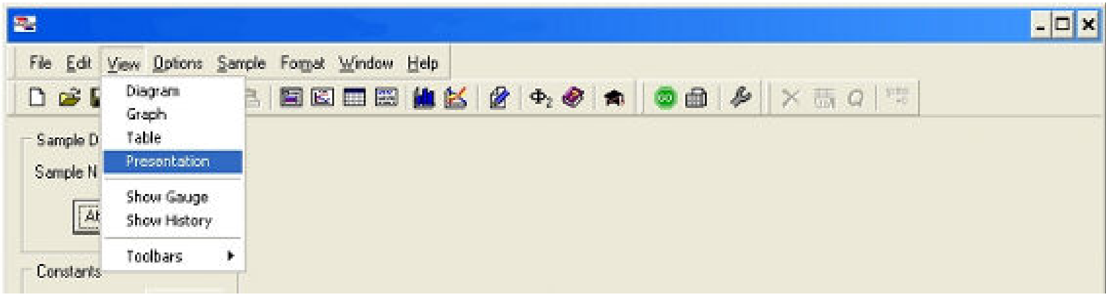
Before proceeding to operate the software ensure that **IFD: OK** is displayed at the bottom of the screen. If IFD:ERROR is displayed check the USB connection between the IFD5 and the PC and confirm that the red and green LED's are both illuminated. If the problem persists then check that the driver is installed correctly (refer to the Operation manual).

Presentation Screen - Basics and Navigation

As stated above, the software starts with the Presentation Screen displayed. The user is met by a simple presentation which gives them an overview of the capabilities of the equipment and software and explains in simple terms how to navigate around the software and summarizes the major facilities complete with direct links to detailed context sensitive 'help' texts.

To view the presentations click **Next** or click the required topic in the left hand pane as appropriate. Click **More** while displaying any of the topics to display a Help index related to that topic.

To return to the Presentation screen at any time click the View Presentation icon  from the main tool bar or click **Presentation** from the dropdown menu as shown:



For more detailed information about the presentations refer to the **Help** available via the upper toolbar when operating the software.

Toolbar

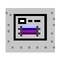
A toolbar is displayed at the top of the screen at all times, so users can jump immediately to the facility they require, as shown:

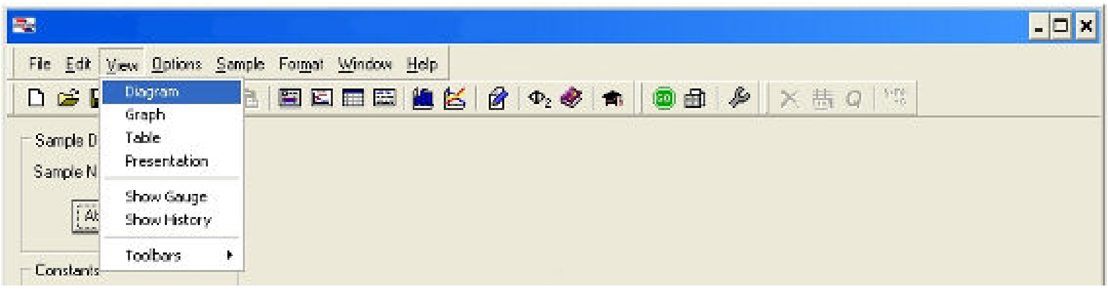
The upper menu expands as a dropdown menu when the cursor is placed over a name.

The lower row of icons (standard for all Armfield Software) allows a particular function to be selected. To aid recognition, pop-up text names appear when the cursor is placed over the icon.

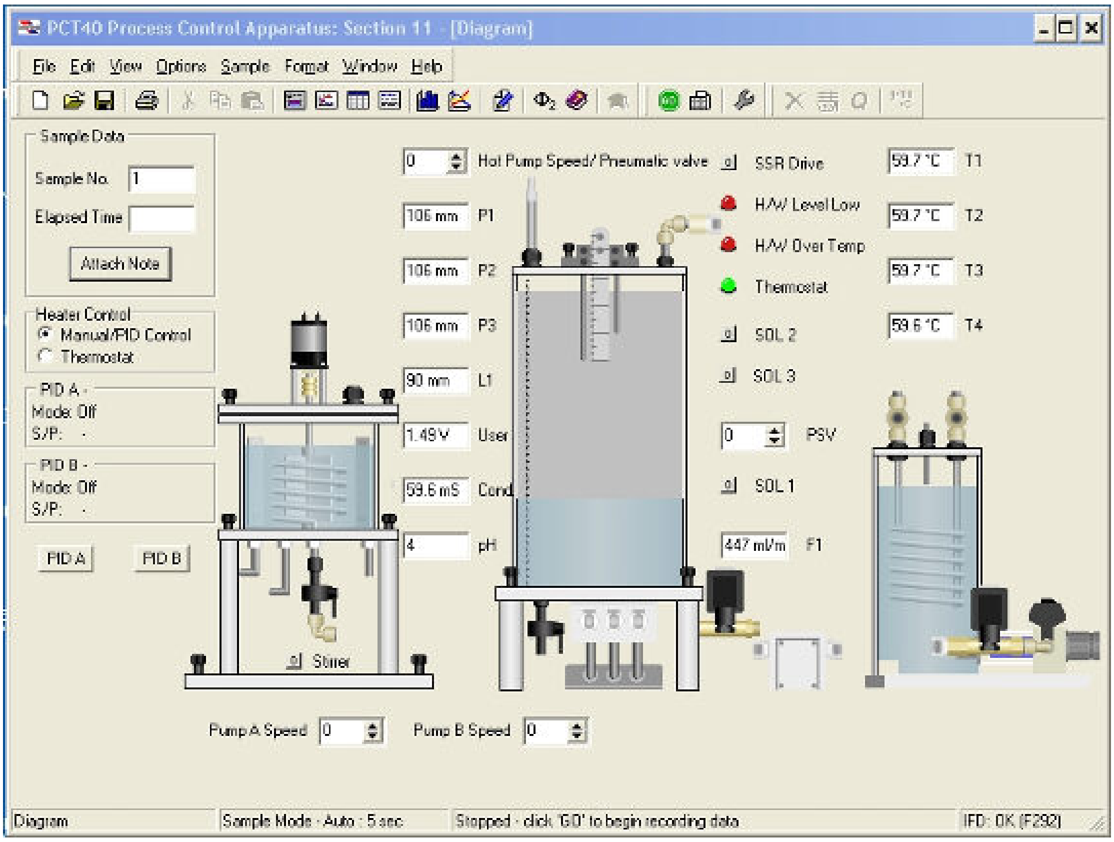
Mimic Diagram

The Mimic Diagram is the most commonly used screen and gives a pictorial representation of the equipment, with continuously updated display boxes for all the various sensor readings, calculated variables etc. directly in engineering units.

To view the Mimic Diagram click the View Diagram icon  from the main tool bar or click **Diagram** from the **View** drop-down menu as shown:



A Mimic diagram is displayed, similar to the diagram as shown:



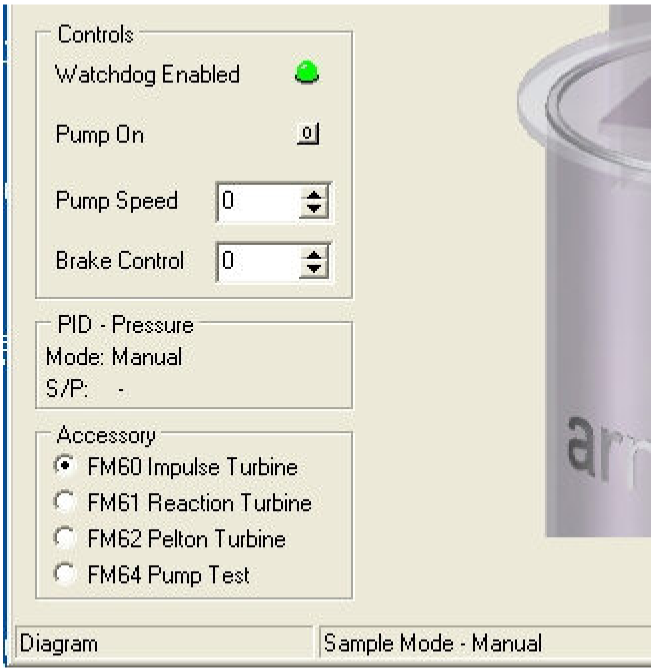
The details in the diagram will vary depending on the experiment chosen if multiple experiments are available.

In addition to measured variables such as Temperature, Pressure and Flowrate (from a direct reading flowmeter), calculated data such as Motor Torque, Motor Speed and Discharge / Volume flowrate (from pressure drop across an orifice plate) are continuously displayed in data boxes with a white background. These are automatically updated and cannot be changed by the user.

Manual data input boxes with a coloured background allow constants such as Orifice Cd and Atmospheric Pressure to be changed by over-typing the default value, if required.

The data boxes associated with some pressure sensors include a **Zero** button alongside. This button is used to compensate for any drift in the zero value, which is an inherent characteristic of pressure sensors. Pressing the **Zero** button just before starting a set of readings resets the zero measurement and allows accurate pressure measurements to be taken referenced to atmospheric pressure. This action must be carried out before the motor is switched on otherwise the pressure readings will be offset.

The mimic diagram associated with some products includes the facility to select different experiments or different accessories, usually on the left hand side of the screen, as shown:



Clicking on the appropriate accessory or exercise will change the associated mimic diagram, table, graphs etc to suit the exercise being performed.

Control Facilities in the Mimic Diagram

A **Power On** button allows the motor to be switched off or on as required. The button always defaults to off at startup. Clicking this button switches the power on (1) and off (0) alternately.

A box marked **Motor Setting** allows the speed of the motor to be varied from 0 to 100% either stepwise, by typing in values, or using the up / down arrows as appropriate. It is usual to operate the equipment with the motor initially set to 100%, then reduce the setting as required to investigate the effect of reduced speed on performance of the equipment.

When the software and hardware are functioning correctly together, the green LED marked **Watchdog Enabled** will alternate On and Off. If the Watchdog stops alternating then this indicates a loss of communication between the hardware and software that must be investigated.

Details on the operation of any automatic PID Control loops in the software are included later in this section.

Data Logging Facilities in the Mimic Diagram

There are two types of sampling available in the software, namely Automatic or Manual. In **Automatic logging**, samples are taken regularly at a preset but variable interval. In **Manual logging**, a single set of samples is taken only when requested by the operator (useful when conditions have to be changed and the equipment allowed to stabilize at a new condition before taking a set of readings).

The type of logging will default to manual or automatic logging as appropriate to the type of product being operated.

Manual logging is selected when obtaining performance data from a machine where conditions need to stabilize after changing appropriate settings. To record a set of set of data values from each of the measurement sensors click the 

icon from the main toolbar. One set of data will be recorded each time the 

icon is clicked.

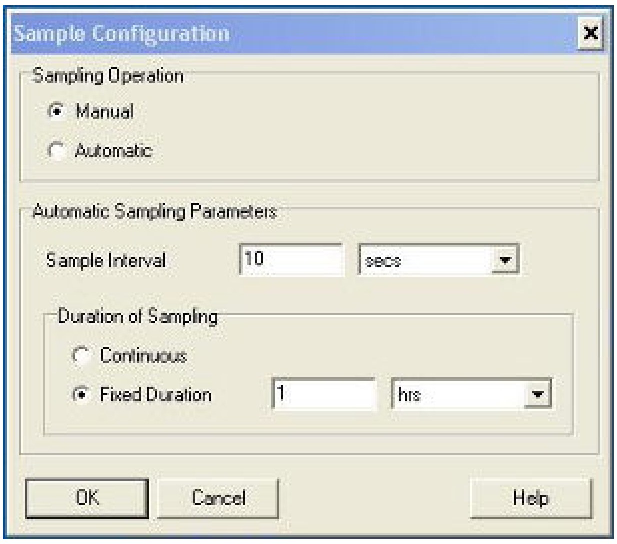
Automatic logging is selected when transients need to be recorded so that they can be plotted against time. Click the 

icon from the toolbar to start recording, click the 

icon from the toolbar to stop recording.

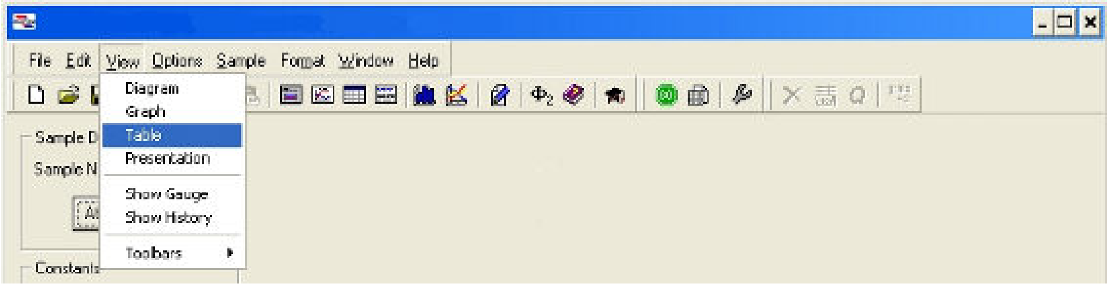
The type of logging can be configured by clicking **Configure** in the **Sample** drop-down menu from the upper toolbar as shown:

In addition to the choice of Manual or Automatic sampling, the parameters for Automatic sampling can also be set. Namely, the time interval between samples can be set to the required number of minutes or seconds. Continuous sampling can be selected, with no time limit or sampling for a fixed duration can be set to the required number of hours, minutes or seconds as shown:

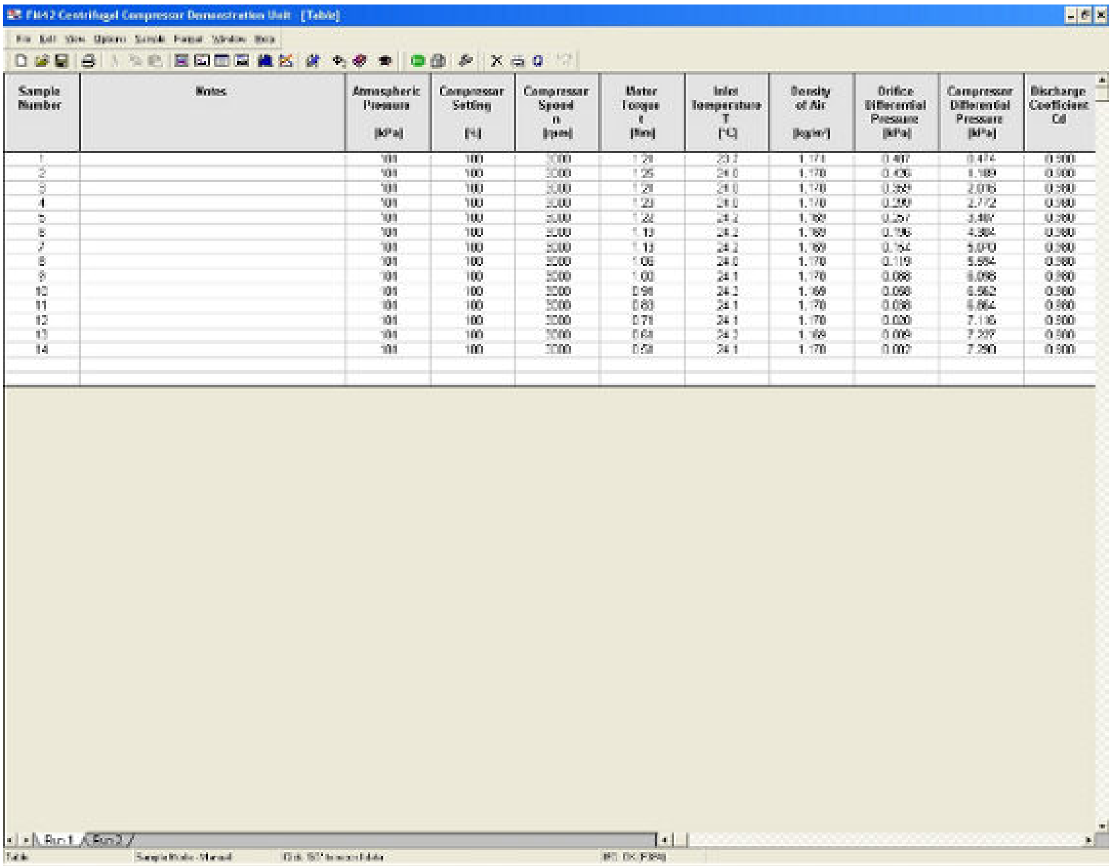


Tabular Display

To view the Table screen click the View Table icon  from the main tool bar or click Table from the View dropdown menu as shown:



The data is displayed in a tabular format, similar to the screen as shown:



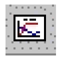
As the data is sampled, it is stored in spreadsheet format, updated each time the data is sampled. The table also contains columns for the calculated values.

New sheets can be added to the spreadsheet for different data runs by clicking the icon from the main toolbar. Sheets can be renamed by double clicking on the sheet name at the bottom left corner of the screen (initially Run 1, Run 2 etc) then entering the required name.

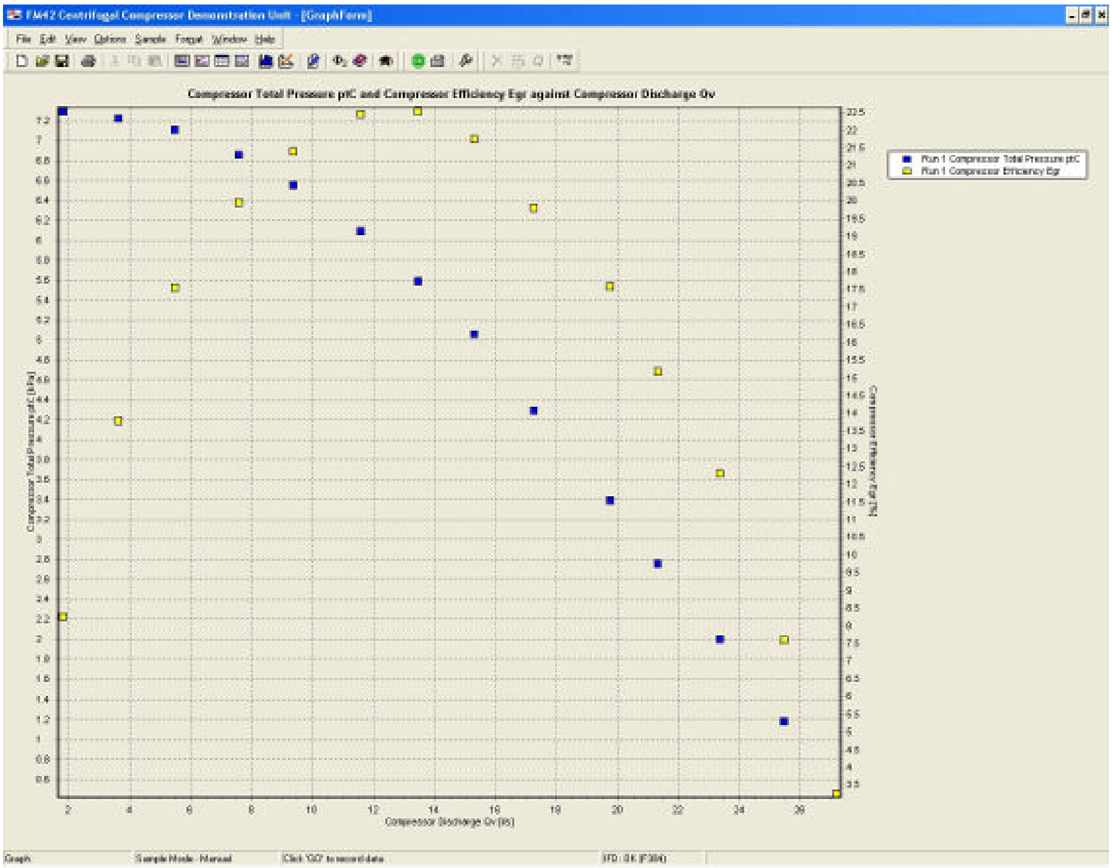
For more detailed information about Data Logging and changing the settings within the software refer to the **Help** available via the upper toolbar when operating the software.

Graphical Display

When several samples have been recorded, they can be viewed in graphical format.

To view the data in Graphical format click the View graph icon  from the main tool bar or click **Graph** from the **View** drop-down menu as shown:

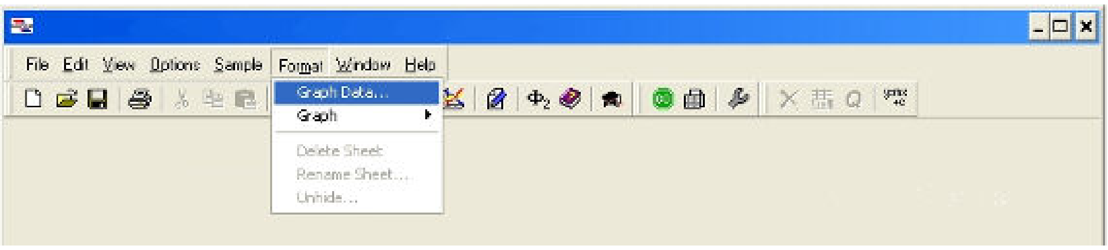
The results are displayed in a graphical format as shown:



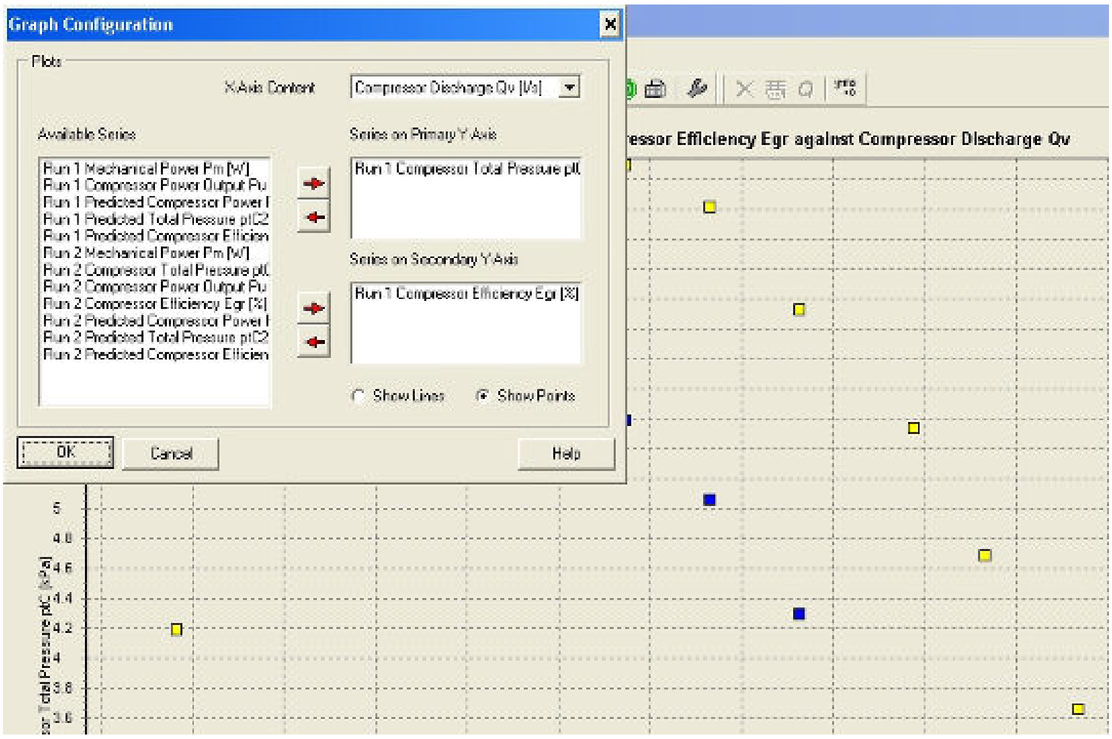
(The actual graph displayed will depend on the product selected and the exercise that is being conducted, the data that has been logged and the parameter(s) that has been selected).

Powerful and flexible graph plotting tools are available in the software, allowing the user full choice over what is displayed, including dual y axes, points or lines, displaying data from different runs, etc. Formatting and scaling is done automatically by default, but can be changed manually if required.

To change the data displayed on the Graph click **Graph Data** from the **Format** dropdown menu as shown:



The available parameters (Series of data) are displayed in the left hand pane as shown:



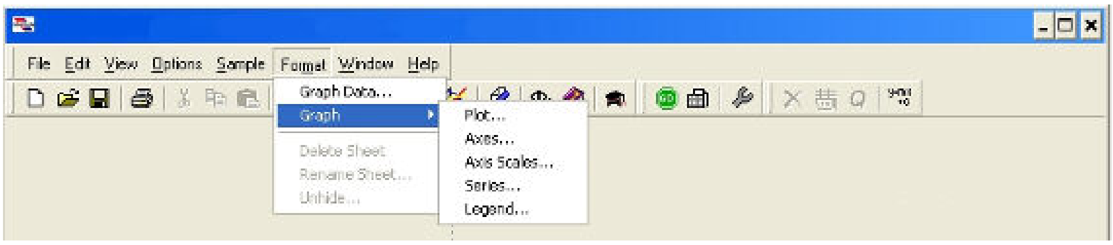
Two axes are available for plotting, allowing series with different scaling to be presented on the same x axis.

To select a series for plotting, click the appropriate series in the left pane so that it is highlighted then click the appropriate right-facing arrow to move the series into one of the windows in the right hand pane. Multiple series with the same scaling can be plotted simultaneously by moving them all into the same window in the right pane.

To remove a series from the graph, click the appropriate series in the right pane so that it is highlighted then click the appropriate left-facing arrow to move the series into the left pane.

The X-Axis Content is chosen by default to suit the exercise. The content can be changed if appropriate by opening the drop down menu at the top of the window.

The format of the graphs, scaling of the axes etc. can be changed if required by clicking **Graph** in the **Format** drop-down menu as shown:

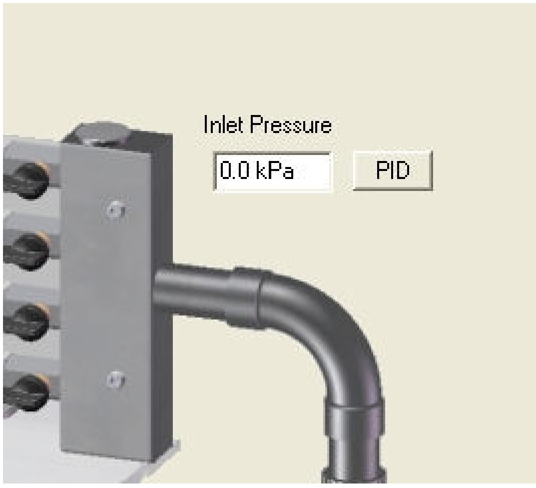


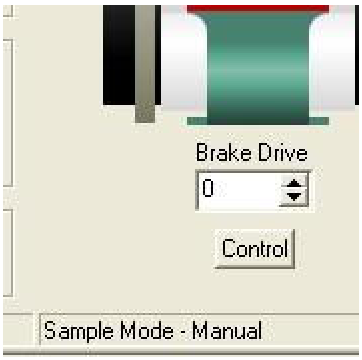
For more detailed information about changing these settings refer to the **Help** available via the upper toolbar when operating the software.

PID Control

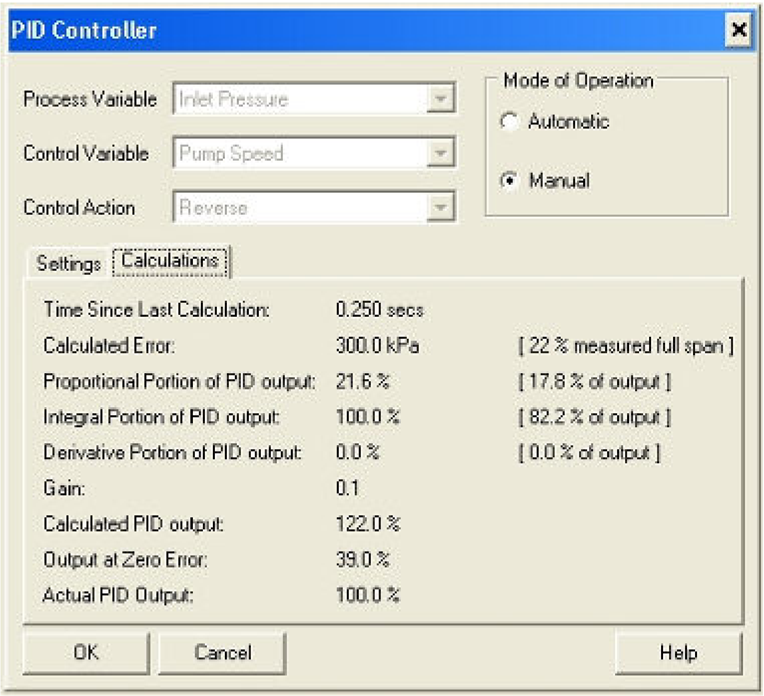
Where appropriate, the software associated with some products will include a single or multiple PID control loops whereby a function on the product can be manually or automatically controlled using the PC by measuring an appropriate variable and varying a function such as a heater power or pump speed.

The PID loop can be accessed by clicking the box labelled **PID** or **Control** depending on the particular software:





A PID screen is then displayed as shown:



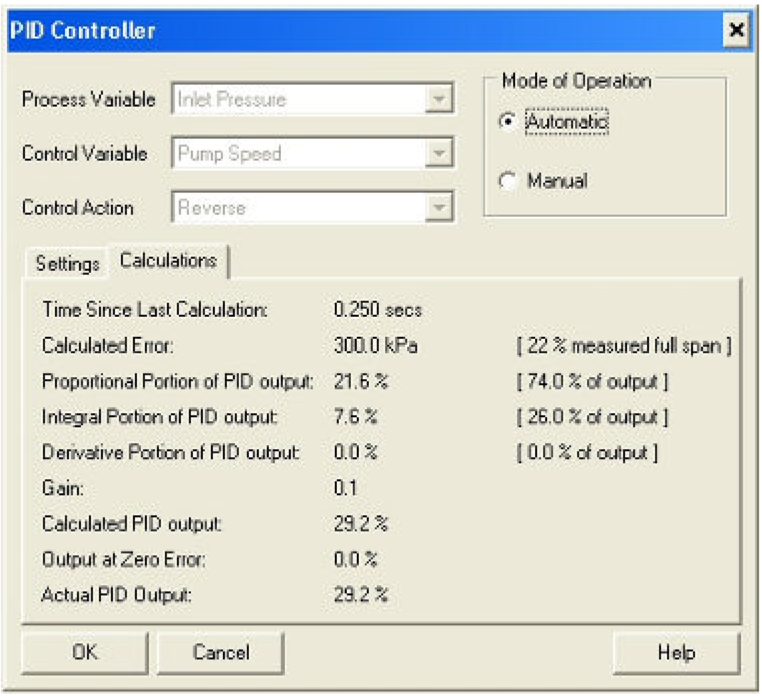
The Mode of operation always defaults to **Manual** control and 0% output when the software is loaded to ensure safe operation of the equipment. If appropriate, the operator can retain manual operation and simply vary the value from 0 to 100% in the **Manual Output** box, then clicking **Apply**.

Alternatively, the PID loop can be changed to Automatic operation by clicking the **Automatic** button. If any of the PID settings need to be changed from the default values then these should be adjusted individually before clicking the **Apply** button.

The controller can be restored to manual operation at any time by clicking the **Manual** button. The value in the **Manual Output** box can be changed as required before clicking the **Apply** button.

Settings associated with Automatic Operation such as the **Setpoint, Proportional Band, Integral Time, Derivative Time** and **Cycle Time** (if appropriate) can be changed by the operator as required before clicking the **Apply** button.

Clicking **Calculations** displays the calculations associated with the PID loop to aid understanding and optimization of the loop when changing settings as shown:



Clicking **Settings** returns the screen to the PID settings.

Clicking **OK** closes the PID screen but leaves the loop running in the background.

In some instances the **Process Variable, Control variable** and **Control Action** can be varied to suit different exercises, however, in most instances these boxes are locked to suit a particular exercise. Where the variables can be changed the options available can be selected via a drop-down menu.

Advanced Features

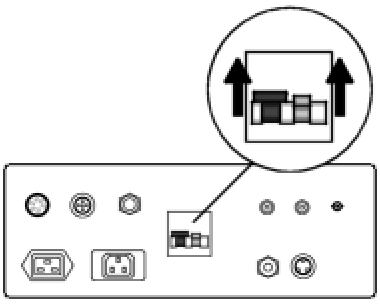
The software incorporates advanced features such as the facility to recalibrate the sensor inputs from within the software without resorting to electrical adjustments of the hardware. For more detailed information about these advanced functions within the software refer to the **Help** available via the upper toolbar when operating the software.

Operating the Equipment

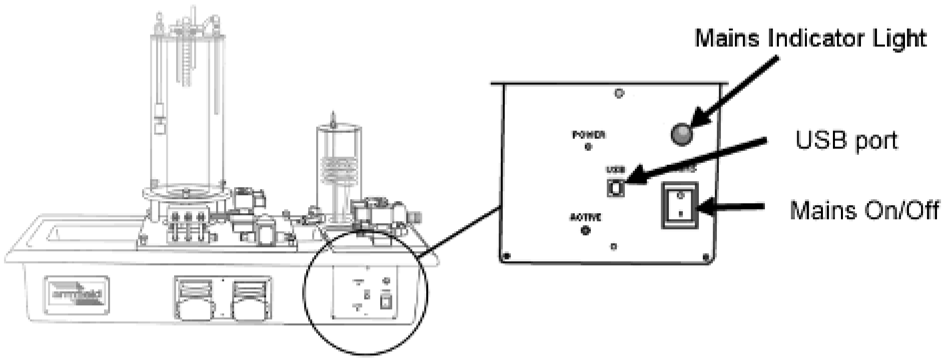
Note: Before operating the equipment ensure that it has been correctly installed in accordance with the Installation Process, and that you have read the Important Safety Information at the beginning of this manual.

Switching On

Before operating the apparatus, check that the RCD and circuit breakers at the back of the equipment are in the ON (up) position:



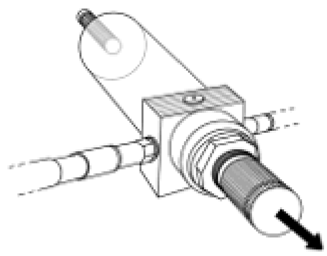
The on/off switch for the apparatus is located on the orange panel on the front of the plinth.



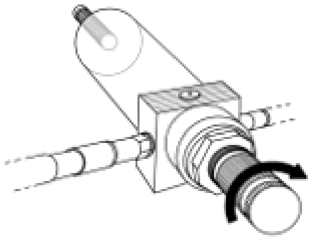
NOTE: The red and green LCD indicators on the front of the plinth are associated with the USB connection to the PC. These may be lit even if the PCT40 unit itself is switched off.

Setting the Pressure Regulator

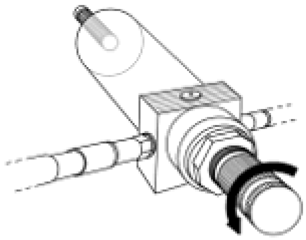
Before adjusting the flow rate through the pressure regulator, pull out the grey knob on the right hand side of the regulator (when looking at the plinth from the front):



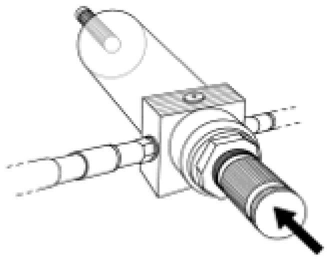
To increase flow through the pressure regulator, turn the knob slowly in a clockwise direction (looking at end of knob). The flow rate is measured by a flow meter downstream of the pressure regulator, and is indicated in L/min on the PCT40 software screen. Flow through the pressure regulator should not be taken above 1.5 L/min as this is the measurement limit of the flow meter. A maximum of 1.4 L/min is recommended.



To reduce the flow rate through the pressure regulator, turn the knob slowly in an anticlockwise direction (looking at end of knob):

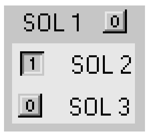


Once the appropriate flow rate is achieved, lock the regulator setting by pushing the grey knob back towards the body of the regulator:



Operating the On/Off Solenoid Valves

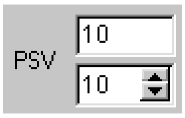
There are three On/Off Solenoid Valves on the base unit. SOL1 is located near the mains water inlet. SOL2 and SOL3 are located near the base of the large process vessel. When required for a teaching exercise, the valves are operated from the mimic diagram screen in the PCT40 software. The switches are represented as buttons on the screen, and are operated by clicking on them with the cursor. The switches will display a ‘0’ when the valves are off (closed) and a ‘1’ when the valves are on (open).



Some exercises include PID control of one solenoid valve. In these exercises the valve is controlled via the PID control window, and the switch is displayed onscreen only to give an indication of whether the switch is in the on or off position.

Operating the Proportioning Solenoid Valve

The Proportioning Solenoid Valve, PSV, is located near the mains water inlet. When required for the teaching exercise being undertaken, this valve is operated from the mimic diagram screen in the PCT40 software. The controls for the valve are represented by a text display box showing the current setting of the valve as a percentage value. For exercises requiring manual control of the PSV valve a second display box will include arrow buttons to increase (up arrow) the value or to decrease (down arrow) the value. New values may also be typed into this second box.



Some exercises include PID control of the proportioning solenoid valve. In these exercises the valve is controlled via the PID control window, and the control boxes are displayed onscreen only to give an indication of the valve position and (where applicable) the current manual setting.

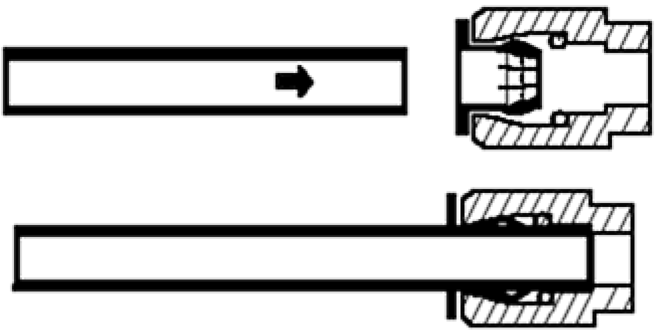
Filling the Process Vessels

The process vessels may if required be filled manually by removing the lid and pouring water in from the top. The large process vessel may also be filled via the tappings in the base from the mains inlet pipe. The small process vessel may be filled from the mains inlet pipe via one of the quick release fittings in the side wall. These may be connected to solenoid valve 1 (SOL1) or the Proportioning Solenoid Valve (PSV), and the valve may then be used to regulate flow from the mains inlet into the process vessel.

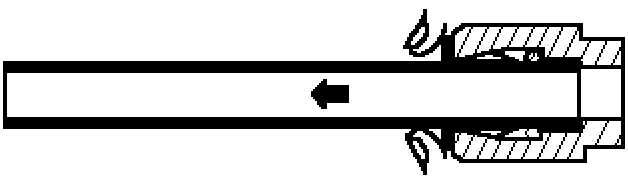
The teaching exercises provided in this manual include instructions for filling the vessel(s) as required.

Using the Guest Push Fittings

Tubes that may be connected to a Guest push fitting require a corresponding rigid tube coupling on the end of the tube. Align the parallel section of the rigid tube with the loose collet on the Guest push fitting and push firmly until the tube stops.

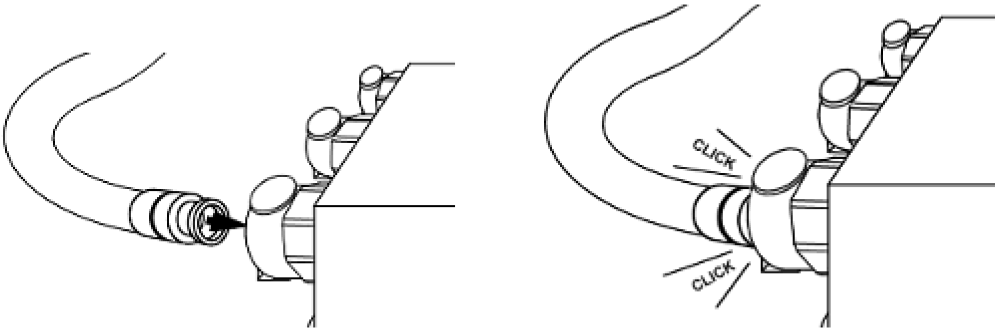


To remove the tube, push the loose circular collet against the body of the Guest push fitting while pulling the tube firmly. The tube will slide out from the fitting. The tube/fitting can be assembled and disassembled repeatedly without damage.

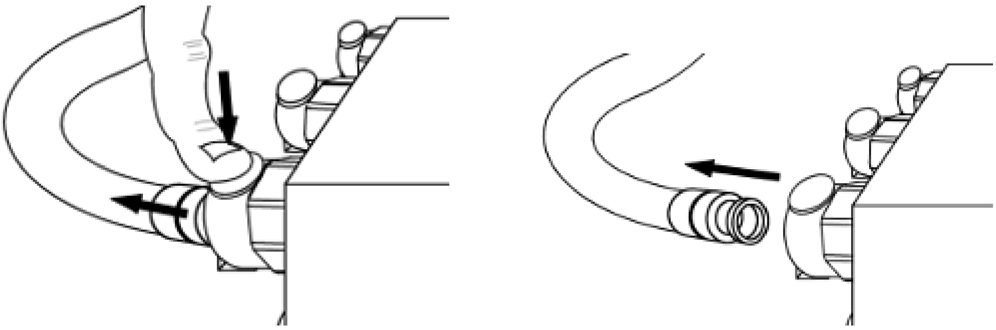


Using the Quick Release Fittings

Tubes to be attached to one of the quick release sockets require a corresponding male coupling on the end of the tube. To connect a tube, push the end of the tube into the socket until an audible click is heard.



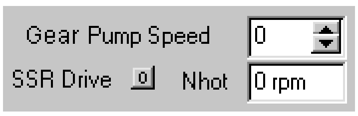
To remove a tube, press the metal catch against the socket and pull the tube free.



Where appropriate, some quick release fittings incorporate a self-sealing valve to prevent loss of fluid when the fitting is disconnected.

Controlling the Gear Pump

When required for a teaching exercise, the gear pump is controlled from the mimic diagram screen in the PCT40 software. The pump setting is displayed as a percentage value and a value in revolutions per minute. The required setting may be typed directly into the percentage display box, or adjusted up or down using the arrow keys attached to the box.



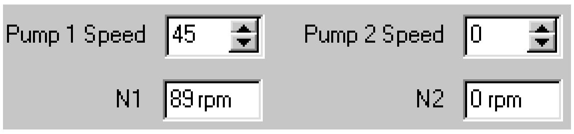
Some exercises include PID control of the gear pump. In these exercises the pump is controlled via the PID control window, and the control boxes are displayed onscreen only to give an indication of the pump speed and (where applicable) the current manual setting.

Using the Peristaltic Pumps

To insert flexible tubing into the pump head:

Raise the cover on the pump head. Adjust the knurled screw at each side until the indicator aligns with the tube size is indicated (6.3 mm inside diameter in the case of PCT40). Lay the tube over the rollers then carefully close the pump head ensuring that the tubing is not trapped and is located centrally in the vee at each side. Not that only the silicon tubing with 1.6 mm wall thickness can be used in the peristaltic pumps.

For teaching exercises that use the peristaltic pumps, the pumps are controlled from the mimic diagram screen in the PCT40 software. The pump settings are displayed as percentage values and a value in revolutions per minute. The required settings may be typed directly into the percentage display box, or adjusted up or down using the arrow keys attached to the boxes. A fault light is also displayed in the software, which will light if a fault is detected with the pump.



Some exercises include PID control of one peristaltic pump. In these exercises the pump is controlled via the PID control window, and the control boxes are displayed onscreen only to give an indication of the valve position and (where applicable) the current manual setting.

Operating the Heating Element

The heating element operates on a simple On/Off switch. When required for a particular teaching exercise it is controlled from the mimic diagram screen in the PCT40 software. The switch is represented as a button on the screen, and is operated by clicking on it with the cursor. The switch will display a ‘0’ when the heating element is off and a ‘1’ when the element is on.

Some exercises include PID control of the heater. In these exercises the heater is controlled via the PID control window, and the switch is displayed onscreen only to give an indication of whether the heater is on or off.

The heating element may also be controlled using the thermostat mounted on the lid of the small process vessel, as described below.

Use of the Thermostat (Temperature Switch)

A thermostat is mounted on the lid of the small process vessel. In some exercises, the heating element is controlled using this thermostat. The thermostat switches the heater on when the temperature in the vessel is below a Set Point value, and off when the temperature is above that value. The Set Point may be selected using the circular selector on top of the thermostat. Thermostat control may be selected in the software by selecting the Thermostat radio button on the mimic diagram screen of the software:

Use of the Differential Pressure Sensors

When required, the outputs from the differential pressure sensors are displayed on the mimic diagram screen in the PCT40 software. The pressure sensors are located inside the manifold block in front of the large process vessel, and each is used in conjunction with an orifice within the block. P1 and P2 are only used for small flowrates associated with PCT41. To direct flow through the large orifice / P3, connect the outlet flow from the peristaltic pump to the self-sealing fitting front of the manifold block, as described in the appropriate teaching exercise. Connect another tube to the Guest push fitting on the back of the manifold and direct the outlet flow as required for the exercise. The internal pressure sensor will then provide the differential pressure between the opposite sides of the orifice. Note that the downstream connection from the orifice to P3 incorporates an in-line quick release connector. In normal use this is connected to give differential pressure that is related to flow. Alternatively the connection can be broken, with the sensor vented to atmosphere to allow line pressure to be measured. In some exercises, the second pump is connected to the upstream side of the orifice using the connector on the right hand end of the block.

Emptying tubes with self-sealing ends

Some of the tubes supplied with the equipment have self-sealing ends. This prevents any fluid from draining out of the apparatus when changing the configuration of the plumbing. However, it also prevents water draining naturally from the tubing when the tubing is not in use. It is therefore recommended that the tubing be manually drained if the equipment is not to be used for some time, to prevent any possibility of harmful micro-organisms building up inside the trapped water.

Self-sealing fittings may be manually drained as follows:

Hold both ends of the tubing over a suitable sink or drain.

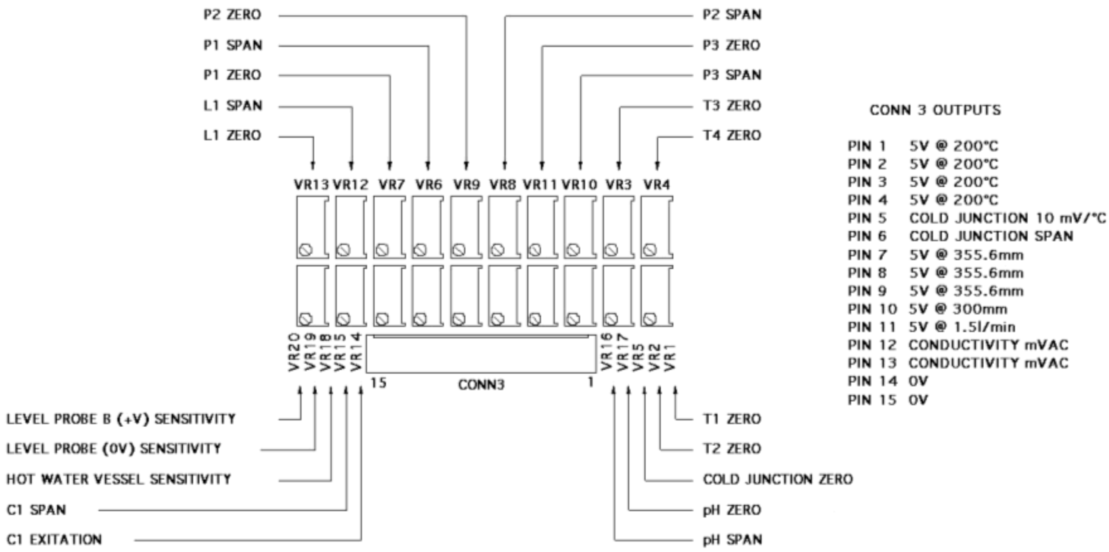
Depress the ends of both self-sealing fittings, taking care not to completely block the ends, allowing water to drain.

Tilt the tube until all the water has drained out.

The tubing can now safely be stored until needed.

Calibration of the sensor conditioning circuits

Zero and Span potentiometers for the sensor conditioning circuits are grouped together at the right hand end of the bottom moulded plinth section. These controls can be accessed by removing the small cover plate. The location of the potentiometers is shown on a diagram attached to the rear of the cover plate. The diagram is included below for information.



Note: The software supplied with the PCT40 includes the ability to recalibrate each of the sensors if necessary. Small changes in calibration should therefore be made using the software. Re-calibration using the potentiometers should not therefore be necessary unless a large change is required such as following the replacement of a sensor etc.

DAC Programming

A 12-bit DAC (Digital to Analogue Converter) Chip is used to control the Gear Pump and PSV on the PCT40.

The chip is model number LTC1456. A datasheet can be found on the Internet by entering the part number into a search engine such as Google.

The required output must first be coded into binary. The output can be from 0 to 4095.

All three lines should be set low (0). The most significant bit (MSB) should then be set on line 2, and then a clock pulse should be sent on line 1. This is repeated until the least significant bit (LSB) has been sent and clocked.

A load pulse should then be sent on line 3.

However, on PCT40, two chips are used in series, and so 24 bits must be sent before the load pulse. The first 12 bits will control the hot water pump, and the last 12 will control the solenoid valve.

Connections using flexible tubes

A set of flexible tubes is supplied with the PCT40. The tubes vary in material, length terminations etc and are used in different applications on PCT40. The tubes are listed below with a brief description and details of their application.

2 x 2.5m long flexible silicone rubber tube, 6.3mm bore, 1.6mm wall (Unsealed quick release fittings both ends). Used in peristaltic pumps A and B.

2 x 2m long flexible clear PVC tubes (90 degree Guest push fitting / plain end). Used to connect outlet of SOL2 and SOL3 to drain

2 x 1m long flexible clear PVC tubes (Sealed quick release fittings both ends). Used to connect between different vessels / control devices.

1 x 2m long flexible clear PVC tube (Guest push fitting / plain end). Used to connect T4 or P3 to drain.

1 x 1m long flexible clear PVC tube (Guest push fitting / unsealed quick release fitting). Used for connecting inlet of coil (T2) to control device E.g. SOL1.

1 x 2m long flexible clear PVC tube (Unsealed quick release fitting / Guest push fitting with flow control valve). Used to connect outlet of coil (T3) or small process vessel to drain with valve to vary flowrate when required.

1 x 1.5m long flexible clear PVC tube (9 mm ID, Plain end / plain end). Used to connect drain valve in moulded channel to drain

1 x 4m long flexible clear PVC tube (Unsealed quick release fitting / Guest push fitting). Used as a holding tube when connected between T3 and T4.

Equipment Specifications

Overall Dimensions

Height : 0.725 m

Width : 1.000 m (plinth)

Depth : 0.530 m (plinth plus pumps)

Electrical Supply

The equipment requires connection to a single phase, fused electrical supply.

Model	**PCT40-A**	**PCT40-B**	**PCT40-G**
GREEN/YELLOW	Earth (Ground)	Earth (Ground)	Earth (Ground)
BROWN	Live (Hot)	Live (Hot)	Live (Hot)
BLUE	Neutral	Neutral	Neutral (Hot)
Fuse Rating	10 AMP	20 A	10 A
Voltage	220-240V	110-120V	220V
Frequency	50 Hz	60 Hz	60 Hz

I/O Port Pin Connections

The 60 way I/O connector at the right-hand end of the moulded plinth carries the control signals to / from accessories such as the PCT43 Electronic Console. This connector can be used to connect other devices to the PCT40 if required for project work etc. The pin-outs on the connector are as follows:

Pin No	**Channel No**	**PCT43 Function**	**Signal**	**Eng Unit**
1	Channel 0	Temperature T1	0 – 5V	0 –200 ^{o}C
2	Channel 1	Temperature T2	0 – 5V	0 –200 ^{o}C
3	Channel 2	Temperature T3	0 – 5V	0 –200 ^{o}C
4	Channel 3	Temperature T4	0 – 5V	0 –200 ^{o}C
5	Channel 4	Pressure P1	0 – 5V	0 – 355.6 mm
6	Channel 5	Pressure P2	0 – 5V	0 – 355.6 mm
7	Channel 6	Pressure P3	0 – 5V	0 – 355.6 mm

8	Channel 7	Level L1	0 – 5V	0 – 300 mm
9	Channel 8	Flowrate F1	0 – 5V	0 – 1.5 l/min
10	Channel 9	USER INPUT	0 – 5V	-
11	Channel 10	Conductivity	0 – 5V	0 – 200 mS
12	Channel 11	pH	0 – 5V	0 – 14 pH
13	Channel 12	Not used		
14	Channel 13	Not used		
15	Channel 14	Not used		
16	+5V Out	+5V Supply		
17	Analog ground	0V		
18	Amp Lo	0V		
19	+12V Out	+12V Supply		
20	-12V Out	-12V Supply		
21	Power Ground	0V		
22	DAC0 Output	Pump A Speed	0 – 5V	RPM
23	DAC0 Ground	0V		
24	DAC1 Output	Pump B Speed	0 – 5V	RPM
25	DAC1 Ground	0V		
26	Digital Ground			
27	Digital Ground			
28	Digital Input Line 0	Not used		
29	Digital Input Line 1	Not used		
30	Digital Input Line 2	HW Vessel Low Level		
31	Digital Input Line 3	HW Vessel Over Temp		

32	Digital Ground	0V		
33	Digital Input Line 4	Thermostat on/off		
34	Digital Input Line 5	Level switch on/off		
35	Digital Input Line 6	Not used		
36	Digital Input Line 7	Diff Level Switch on/off		
37	Digital Ground	0V		
38	Digital Output Line 0	DAC-CLK (Hot water pump and PSV control)		
39	Digital Output Line 1	DAC-Din (Hot water pump and PSV control)		
40	Digital Output Line 2	DAC-CS/LD (Hot water pump and PSV control)		
41	Digital Output Line 3	SSR Drive		
42	Digital Ground			
43	Digital Output Line 4	Solenoid valve SOL1 on/off		
44	Digital Output Line 5	Solenoid valve SOL2 on/off		
45	Digital Output Line 6	Solenoid valve SOL3 on/off		
46	Digital Output Line 7	PCT41 Stirrer on/off		
47	Digital Ground	0V		
48	Aux Output 1	USB/PCT43 Control		
49	Aux Output 2	Gear Pump or PCT44 valve	0 – 5V	

50	Aux Output 3	PSV Control	0 – 5V	
51		+24V Supply		
52		+24V Supply		
53		+24V Supply		
54		0V		
55		0V		
56		0V		
57		+12V Supply		
58		+5V Supply		
59		-12V Supply		
60		0V		

Other Specifications

Temperature sensors T1 – T4	Type k, 0 – 200 ^{o}C
Pressure sensor L1	Piezo, 0 - 300 mm H2O (gauge)
Pressure sensors P1 – P3	Piezo, 0 - 355.6 mm (differential)
Turbine flowmeter	0.2 – 1.5 litres/min
Solenoid valve SOL1	Orifice 2.4 mm diameter
Solenoid valve SOL2	Orifice 2.4 mm diameter
Solenoid valve SOL3	Orifice 3.2 mm diameter
Proportioning Solenoid Valve	Orifice 2.4 mm diameter
Peristaltic Pump Flow rate (6.3 mm ID tube)	0 – 1.3 litres/min (nominal)
Large Process Vessel Capacity (Full)	6.8 litres (nominal)
Large Process Vessel Capacity (Reduced)	4 litres (nominal)

Heater power (small process vessel)	2 kW (nominal)
Maximum hot water temperature	80 ^{o}C (nominal)

Environmental Conditions

This equipment has been designed for operation in the following environmental conditions. Operation outside of these conditions may result reduced performance, damage to the equipment or hazard to the operator.

a. Indoor use;

b. Altitude up to 2000 m;

c. Temperature 5 °C to 40 °C;

d. Maximum relative humidity 80 % for temperatures up to 31 °C, decreasing linearly to 50 % relative humidity at 40 °C;

e. Mains supply voltage fluctuations up to ±10 % of the nominal voltage;

f. Transient over-voltages typically present on the MAINS supply;

Note: The normal level of transient over-voltages is impulse withstand (over-voltage) category II of IEC 60364-4-443;

g. Pollution degree 2.

Normally only nonconductive pollution occurs.

Temporary conductivity caused by condensation is to be expected.

Typical of an office or laboratory environment

Routine Maintenance

Responsibility

To preserve the life and efficient operation of the equipment it is important that the equipment is properly maintained. Regular maintenance of the equipment is the responsibility of the end user and must be performed by qualified personnel who understand the operation of the equipment.

General

The equipment should be disconnected from the electrical supply when not in use.

The process vessels, optional reactor vessel, heating/cooling coil and pipework should be drained after use. Water pumped through the equipment will remove chemical deposits from the pumps, flowmeter, supply lines etc.

In areas of hard water, the amount of scale in the process vessels and pipework can be reduced by fitting a de-ioniser in-line with the water supply to the equipment.

After use, release the heads of the peristaltic pumps by pivoting the clamp on the pump head upwards and backwards to expose the rotor. This takes the pressure off the flexible tubing and will prolong the life of the tubing.

The life of the flexible tubing used in the peristaltic pump heads can be extended by moving the tubing through the pump head to an unused section at regular intervals.

When replacement of the flexible tubing is necessary it is important to ensure that the replacement tubing is compatible as follows:

PCT40 exercises

Altec code	01-93-1432
Material	'Altesil' High Strength Silicon Rubber
Wall thickness	1.6 mm
Inside diameter	6.3 mm

PCT41 exercises

Watson Marlow code	913.A032.016
Material	Silicon Rubber
Wall thickness	1.6 mm
Inside diameter	3.2 mm

General connections on Process Plant Trainer

Material	Clear PVC
Inside diameter	6 mm or 9 mm as appropriate

Note: Before attempting to replace the flexible tubing in either peristaltic pump head, ensure that the equipment has been switched off to prevent inadvertent rotation of the rollers.

Before installing the flexible tubing ensure that the adjusters on either side of the pump head (at the bottom) have been set to the diameter of tube in use. (The standard tubing supplied with PCT40 has a bore of 6.3 mm and the tubing supplied with PCT41 has a bore of 3.2 mm so the indicator must align with the 6.4 mark or the 3.2 mark as appropriate when the head is unclamped.) To install or replace the flexible tubing lift the clamp (on the top of the pump head) upwards and backwards to expose the rotor. Load the tubing into the slot between the rotor and pump head then close the pump head by pushing the clamp forwards and downwards. The clamp will click shut. The tube will retain its elasticity for many hours of use but there is sufficient length to allow the tube to be moved to other positions of less wear. It is essential to release the clamp when the equipment is not being used to prevent permanent deformation of the tube.

RCD Test

Test the RCD by pressing the TEST button at least once a month. If the RCD button does not trip when the Test button is pressed then the equipment must not be used and should be checked by a competent electrician.

Cleaning the Equipment

Build-up of scale on the inside of the process vessels can be minimised by drying the vessels when they are to be left unused for some time. Scale that does develop within the large process vessel may be cleaned by hand.

It will be necessary to clean the filter in the pressure regulator at regular intervals. If the filter is visibly obstructed or the inlet flow rate appears reduced then the filter may need cleaning. Remove the filter from the equipment and clean by flushing with clean water flowing in the opposite direction to normal flow. The frequency of cleaning will depend on the cleanliness of the water supply.

Any build up of scale in the pipe work or process vessels can be removed by passing a mild descaler through the system then flushing thoroughly with clean water. Any stubborn deposits in the large process vessel can be eliminated by manual cleaning. Remaining deposits in the smaller vessel may need longer soaking in descaling solution. Always follow the instructions provided with the descaler regarding suitable dilution of the chemical.

The water in both of the process vessels should be drained after use or at least changed at regular intervals to prevent the growth of algae that may present a hazard to health.

Accessing the electrical circuits inside the plinth

Maintenance of the PCT40 does not require access to the electrical circuits or components located inside the moulded plinth. However, in the event of an electrical problem it may be necessary for a competent electrician to gain access to the inside of the mouldings as follows:

Ensure that the equipment is disconnected from the electrical supply (not just switched off).

Drain any liquids contained in the process vessels and reactors, and remove any flexible tubing connected to the pumps, valves etc.

Drain the moulded channel in the plinth via the channel drain valve located in the recess at the left hand end, then unscrew the drain valve and remove it.

Unscrew the six fixings around the periphery of the plinth top.

Carefully raise the front of the top moulded section – the two sections are hinged at the rear. Unclip the prop that is located inside the front of the bottom moulded section then support the top section centrally at the front using the prop. Ensure that the prop is properly located in the appropriate recesses.

The electrical circuits inside the bottom moulded plinth section are accessible for working on.

A circuit diagram showing the mains and DC electrical circuits inside the plinth is included in the Electrical Wiring Diagram to assist in fault finding.

Re-assembly of the top and bottom moulded plinth sections is the inverse of the above instructions.

Freeing a seized hot water pump

In normal use the hot water pump should not require any routine maintenance and running should keep the gears free from scale due to hard water etc. However, if the water is contaminated with flakes of hardness or dirt particles then the gears inside the pump might seize because of the small operating clearances that are necessary. If the hot water pump does not operate when switched on it then it will be necessary to check the pump as follows:

> Disconnect the electrical supply to the equipment.
>
> Disconnect any flexible tubes connected to the gear pump to minimize loss of water when the pump is opened.
>
> Remove the rectangular end cover from the head of the pump by unscrewing the four cap headed screws using a hexagon wrench (Allen key). Any water draining from the pump will drain into the top of the plinth.
>
> Inspect the gears, cover etc for any contamination and clean as necessary but do not use any harsh abrasives or volatile solvents on the plastic gears or the anodized aluminium body.
>
> If it is necessary to remove the plastic gears take care not to damage the gears or to lose the drive key inside the driven gear. If the gears are stubborn to remove then a pair of tweezers or similar tool may be used to extract the gears by grasping one of the flutes.

When the pump is clean replace the gears ensuring that the drive key is correctly located inside the slot in the driven shaft. Ensure that the gears are free to rotate before replacing the end cover.

Ensure that the sealing gasket is correctly located in the groove on the end face of the pump body then replace the end cover and secure it using the four screws.

Reconnect the flexible connections and reconnect the electrical supply. Ensure that the hot water vessel is full with water then check satisfactory operation of the pump.

Laboratory Teaching Exercises

Index to Exercises